Dental Materials Journal 2026; : –

Air abrasion device versus sandblasting device for surface pretreatment of CAD-CAM prosthetic materials

Kentaro NAKAJIMA[1], Yoshiki ISHIDA[1], Daisuke MIURA[1], Yasuhiro HOTTA[1] and Akikazu SHINYA[1,2]

[1] *Department of Dental Materials Science, School of Life Dentistry at Tokyo, The Nippon Dental University, 1-9-20 Fujimi, Chiyoda-ku, Tokyo 102-8159, Japan*

[2] *Department of Prosthetic Dentistry and Biomaterials Science, Institute of Dentistry, University of Turku, Lemminkaisenkatu 2, Turku 20520, Finland*

Corresponding author, Akikazu SHINYA; E-mail: akishi@tky.ndu.ac.jp

This study evaluated the effects of various surface pretreatments using chairside air abrasion with water injection or laboratory sandblasting devices on the shear bond strength of resin luting agents to three CAD-CAM prosthetic materials: resin composites, glass ceramics, and zirconia. Pretreatments included air abrasion with water injection (29 µm or 53 µm alumina or bioactive glass powder), conventional sandblasting with 50 µm alumina, and hydrofluoric acid etching for glass ceramics. Specimens were prepared after embedding the blocks. Surface roughness was measured after pretreatment, and shear bond strength was tested following cementation. Failure modes were analyzed using an optical profilometer. Results showed that air abrasion with 50 µm alumina, whether using a chairside device with water injection or a laboratory sandblasting device, produced comparable bond strength. These findings suggest that chairside air abrasion with 50 µm alumina is a clinically viable alternative to laboratory sandblasting for surface treatment of CAD-CAM prosthetic materials.

Keywords: Air abrasion, Pretreatment, Reactivation, CAD-CAM, Sandblasting

INTRODUCTION

In modern dentistry, the advent of CAD-CAM systems since the 1980s has enabled a fully digital workflow, from optical impressions to the design and fabrication of dental prostheses. This has streamlined treatment procedures compared to traditional methods using impression materials and stone models[1-6)]. Furthermore, CAD-CAM technology has facilitated the use of high-strength ceramic materials—previously difficult to process—allowing the fabrication of restorations that are both durable and esthetic[7,8)]. Commonly used CAD-CAM materials include resin composites, glass ceramics, and zirconia[2,7,9)]. Clinical application of all-ceramic restorations gained popularity, especially zirconia—such as yttria-stabilized tetragonal zirconia polycrystal (Y-TZP)—for its superior mechanical strength, and lithium disilicate glass ceramics for their high translucency and esthetics[10-13)]. In Japan, resin composite blocks have also become available for clinical use since 2014, enabling metal-free restorative options even under national insurance coverage[14)].

Bonding CAD-CAM restorations to abutment teeth requires surface pretreatment of both the abutment and the internal surface of the prosthesis[7)]. Air abrasion using alumina is widely recommended to increase surface area and improve micromechanical interlocking. For ceramics, silane coupling agents enhance chemical adhesion by forming siloxane bonds[12,15-21)] and hydrofluoric acid etching is often used with glass ceramics to selectively dissolve the glassy matrix, improving micromechanical retention[11,13,15,22-27)]. Zirconia, which lacks a silica phase, benefits from tribochemical silica coating followed by silanization[12,13,16,17,20,28-30)].

Traditionally, these surface pretreatments are carried out in the laboratory. Under severe conditions, such as blasting large particles, the surface defects lead to a decrease in the bonding strength[31)]. On the other hand, chairside air abrasion devices that connect directly to dental units have been developed, allowing intraoral or immediate prosthetic surface pretreatment[18)]. Some of these devices can also deliver abrasive particles with water to reduce aerosol dispersion[32)]. A previous study reported that blasting without a solution causes thermal damage by hitting the particle, leading to the blackening of the tooth structure. However, air abrasion, which involves blasting the particle with a solution, could help avoid surface defects caused by hitting the particle[33)]. In addition, these devices accommodate various abrasive powders, such as minimally abrasive bioactive glass (used for cleaning tooth surfaces and promoting remineralization) and highly abrasive alumina [used for cavity preparation and roughening tooth/prosthetic surfaces in accordance with minimal intervention dentistry (MID)][34-38)].

In dentistry, the terms sandblasting device and air abrasion device are frequently used interchangeably, as both devices employ compressed air to deliver a fine stream of abrasive particles for surface modification. Although different terminology is used depending on the clinical context, the underlying mechanism of both systems is identical. They operate on the same kinetic energy principle as industrial sandblasting, in which high-velocity abrasive particles—propelled by compressed air, nitrogen, or helium—remove material from a target surface. Owing to health hazards associated

Received Nov 19, 2025: Accepted Dec 19, 2025
doi:10.4012/dmj.2025-297 JOI JST.JSTAGE/dmj/2025-297

with crystalline silica, modern dental systems do not use actual sand; instead, they rely on medical-grade abrasives such as aluminum oxide, silica-based powders, or sodium bicarbonate mixtures. Clinically, the distinction between the two terms reflects differences in application rather than device design. Air abrasion device commonly refers to minimally invasive preparation techniques, such as removing small carious lesions or old composite restorations, where patient comfort and preservation of sound tooth structure are prioritized. These devices typically employ fine particles (*e.g.*, 29–53 µm alumina) to enable controlled and conservative tissue removal. In contrast, a sandblasting device is used primarily to roughen the surfaces of teeth enamel, indirect restorations, and prosthetic materials—including ceramics, resin composites, and zirconia—to enhance micromechanical retention and bonding effectiveness. Such devices are used both intraorally and extraorally, including in dental laboratory settings before cementation procedures. Despite differences in terminology and clinical focus, both air abrasion and sandblasting devices share comparable delivery systems, abrasive media, and operational principles. Thus, an air abrasion device can be regarded as a specialized dental sandblasting device optimized for precise, minimally invasive procedures, while sandblasting devices are oriented toward surface conditioning for adhesive protocols. Understanding the functional equivalence and application-specific characteristics of these technologies is essential for selecting appropriate surface pretreatment strategies for contemporary CAD-CAM prosthetic materials.

If air abrasion units that can be connected to dental units could be utilized for the surface pretreatment of prostheses, chairside time would be reduced, resulting in improved clinical efficiency. Although the use of air abrasion is well established in laboratory settings, few studies have compared these systems with conventional sandblasting devices used in the laboratory. Moreover, given the wide variety of available abrasive particles and their respective advantages, the opportunities for utilizing air abrasion are likely to increase.

Therefore, the aim of this study was to investigate the differences between air abrasion and sandblasting devices in terms of surface roughness and bond strength between resin luting agents and three CAD-CAM materials: resin composite, glass ceramics, and zirconia. The null hypothesis was that the surface pretreatment method would not significantly influence the bonding performance to these materials.

MATERIALS AND METHODS

Preparation of specimens

The CAD-CAM blocks used in this study are listed in Table 1. Three types of CAD-CAM materials were selected as adherends: resin composite (Katana Avencia N, Kuraray Noritake, Tokyo, Japan), glass ceramics (Initial LiSi Block A2 HT, GC, Tokyo, Japan), and zirconia (SHOFU Disc ZR Lucent Ultra A2, Shofu, Kyoto, Japan). Each material was sectioned into rectangular plates (10×10×3 mm^3) using a low-speed diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA). Zirconia specimens were subjected to final sintering following the manufacturer's instructions. Specimens were embedded in auto-polymerizing acrylic resin (Palapress Vario, Heraeus Kulzer, Hanau, Germany). All specimen surfaces were polished using #600 silicon carbide paper under running water, and the specimens were randomly assigned into five groups (n=15 per group[39)]).

Surface pretreatments

The abrasive powders and equipment used are summarized in Table 2, and the abbreviations for each group are shown in Table 3. Air abrasion was performed using an air abrasion device (AquaCare, Apatite, Tokyo, Japan) with a 0.8 mm tip or a laboratory sandblasting device (Basic Classic, Renfert, Hilzingen, Germany) with 0.8 mm tip. All procedures were performed at 0.3 MPa pressure, from a distance of 10 mm, for 10 s. The detailed procedures for each adherend were described as follows.

Resin composites group

Surface pretreatments included air abrasion device using 29 µm alumina (R-29C), 53 µm alumina (R-53C), and 50–70 µm bioactive glass powder (R-BAG), all applied with water injection. As a positive control (R-50L), 50 µm alumina was applied using the sandblasting device. The negative control group (R-CON) received no surface treatment.

Glass ceramics group

Surface pretreatments included 29 µm alumina (C-29C), 53 µm alumina (C-53C), and 50–70 µm bioactive glass powder (C-BAG) using the air abrasion device under water injection, and 50 µm alumina (C-50L) with the sandblasting device. Hydrofluoric acid etching with 9.5% HF gel (Porcelain Etchant Gel, Bisco, Schaumburg, IL, USA) was performed as a positive control (C-HF), and no treatment was applied in the negative control (C-CON).

Table 1 Adherend materials used in this study

Materials	Manufacturer	Composition (wt%)	Lot No.
Katana Avencia N	Kuraray Noritake Dental, Tokyo, Japan	UDMA, TEGDMA, Light anhydrous silica/ aluminum oxide mixed filler	000105
Initial LiSi Block A2 HT	GC, Tokyo, Japan	$Li_2Si_2O_5$, Li_3PO_4,Cristobalite, Quartz, Glass	2311182
SHOFU Disc ZR Lucent Ultra A2	Shofu, Kyoto, Japan	Zirconium dioxide, Y_2O_3	092103

Table 2 Materials used for air abrasion and sandblasting, and bonding agents in this study

Materials	Manufacturer	Composition (wt%)	Lot No.
Clearfil Ceramic Primer Plus	Kuraray Noritake Dental, Tokyo, Japan	Silane coupling agent, monomer (MDP), ethanol	5Q096
Alumina oxide 29 µm	Medivance Instruments, London, UK	Aluminum oxide	100122
Alumina oxide 53 µm	Medivance Instruments	Aluminum oxide	011222
BioActive Glass Powder	Medivance Instruments	Particle size: 30-60-90 µm, 45% SiO_2, 24.4% CaO, 24.6% Na_2O_2, 6% P_2O_5	091222
Aqua sol	Medivance Instruments	17% ethanol solution	10187
Cobra Aluminum oxide 50 µm	Renfert, Hilzingen, Germany	99.5% Aluminum oxide, 0.06% Silicon dioxide	03210416
Porcelain Etchant gel	Bisco, Schaumburg, IL, USA	9.5% hydrofluoric acid, polyacrylamide, methylpropanesulfonic acid, water	2300111455
Panavia V5 Paste (Universal shade)	Kuraray Noritake Dental	Paste A: Bis-GMA, Hydrophobic aliphatic dimethacrylate, Hydrophilic aliphatic dimethacrylate, TEGDMA Paste B: Bis-GMA, Hydrophobic aromatic dimethacrylate, Hydrophilic aliphatic dimethacrylate	8G0249

Table 3 Abbreviations and conditions for groups tested in this study

Adherends (*n*=15)	Adhesion pretreatment conditions	Group abbreviation
Resin Composite	No air abrasion or sandblasting	R-CON
	Air abrasion with air abrasion device using bioactive powder glass	R-BAG
	Air abrasion with air abrasion device using alumina particles 29 µm	R-29C
	Air abrasion with air abrasion device using alumina particles 53 µm	R-53C
	Sandblasting with laboratory sandblaster device using alumina particles 50 µm	R-50L
Glass Ceramics	No air abrasion or sandblasting, and no HF	C-CON
	Air abrasion with air abrasion device using bioactive powder glass	C-BAG
	Air abrasion with air abrasion device using alumina particles 29 µm	C-29C
	Air abrasion with air abrasion device using alumina particles 53 µm	C-53C
	Sandblasting with laboratory sandblaster device using alumina particles 50 µm	C-50L
	Hydrofluoric acid treatment	C-HF
Zirconia	No air abrasion or sandblasting	Z-CON
	Air abrasion with air abrasion device using bioactive powder glass	Z-BAG
	Air abrasion with air abrasion device using alumina particles 29 µm	Z-29C
	Air abrasion with air abrasion device using alumina particles 53 µm	Z-53C
	Sandblasting with laboratory sandblaster device using alumina particles 50 µm	Z-50L

Zirconia group

The same treatments as described above were used: 29 µm alumina (Z-29C), 53 µm alumina (Z-53C), 50–70 µm bioactive glass powder (Z-BAG) using the air abrasion device under water injection, and 50 µm alumina (Z-50L) using the sandblasting device. No treatment was applied in the Z-CON group.

Surface roughness measurement

Surface roughness (*Ra*) was evaluated before bonding using a surface profilometer (SURFCOM FLEX-50A, Tokyo Seimitsu, Tokyo, Japan). A 4-mm traverse length was scanned at 0.3 mm/s, perpendicular to the specimen surface. The cut-off value was set at 0.8 mm. Each specimen was measured at three locations, and the mean *Ra* value was used for statistical analysis.

Scanning electron microscopy (SEM) observation

Specimens after air abrasion and sandblasting were dried and sputter-coated with osmium (Neo-Osmium

Coater, Meiwa Fosis, Tokyo, Japan). SEM images were obtained using a scanning electron microscope (JSM-IT200LA, JEOL, Tokyo, Japan) at 15 kV accelerating voltage and 10 mm working distance.

Bonding procedure

Specimen surfaces were treated with a ceramic primer (Clearfil Ceramic Primer Plus, Kuraray Noritake). A cylindrical mold (2.4 mm diameter) was placed on the surface and filled with resin luting agent (Panavia V5 Paste, Kuraray Noritake). Light irradiated using a curing light unit (VALO, Ultradent, South Jordan, UT, USA) for 20 s from three directions (total 60 s) at an average of 1,000 mW/cm². Specimens were then stored in ultrapure water at 37°C for 24 h.

Shear bond strength (SBS) test and failure mode analysis

SBS was measured using a universal testing machine (UltraTester, Ultradent Products) at a crosshead speed of 1.0 mm/min. SBS (MPa) was calculated from the peak load (N) divided by bonding area. Fracture surfaces were examined using a 3D optical profilometer (VR-6000, KEYENCE, Osaka, Japan) to classify failure modes.

Statistical analysis

Since the normality and homogeneity of variance were satisfied by Shapiro–Wilk test and Levene's test, the mean values of surface roughness and SBS were analyzed using one-way ANOVA followed by Tukey's multiple comparison test ($\alpha=0.05$) for each material group: resin composites, glass ceramics, and zirconia. Statistical analyses were performed using statistical software (SPSS version 24, IBM, Armonk, NY, USA). A post hoc power analysis was also conducted to determine the statistical power for the sample size ($n=15$).

RESULTS

Surface roughness

Table 4 summarizes the results. In the resin composite group, R-50L showed the highest surface roughness (2.52 µm), while R-CON showed the lowest (0.10 µm, Fig. 1). *Post-hoc* power analysis indicated a high statistical power of 1.000. There was no significant difference between R-CON and R-BAG ($p>0.05$). In the glass ceramics group, C-50L demonstrated the highest surface roughness (1.74 µm), and C-CON the lowest (0.42 µm, Fig. 2). No significant differences were found among C-CON, C-BAG, and C-HF ($p>0.05$). In the zirconia group, Z-50L exhibited the highest surface roughness (0.71 µm), while Z-CON showed the lowest (0.30 µm, Fig. 3).

SEM observation

Figures 4, 5, and 6 show the SEM images of the resin

Table 4 Summary of shear bond strength, surface roughness, and failure modes after shear bond tests

Specimen group	Shear bond strength	Surface roughness	Failure mode
R-CON	9.66 (1.91)	0.10 (0.02)	[0/13/2]
R-BAG	9.63 (1.25)	0.15 (0.08)	[1/11/3]
R-29C	14.87 (2.29)	1.27 (0.04)	[0/15/0]
R-53C	18.13 (0.69)	1.80 (0.07)	[1/11/3]
R-50L	19.35 (2.69)	2.52 (0.11)	[0/13/2]
C-CON	21.36 (7.93)	0.42 (0.12)	[0/12/3]
C-BAG	12.89 (5.07)	0.61 (0.09)	[0/9/6]
C-29C	17.24 (2.40)	1.15 (0.17)	[0/9/6]
C-53C	18.93 (1.89)	1.50 (0.17)	[0/11/4]
C-50L	20.13 (3.01)	1.74 (0.08)	[0/9/6]
C-HF	36.72 (3.83)	0.55 (0.13)	[0/6/9]
Z-CON	17.23 (3.57)	0.30 (0.12)	[0/14/1]
Z-BAG	19.31 (4.20)	0.32 (0.10)	[0/13/2]
Z-29C	20.79 (5.25)	0.43 (0.09)	[0/12/3]
Z-53C	22.83 (5.49)	0.61 (0.13)	[0/12/3]
Z-50L	23.26 (2.45)	0.71 (0.23)	[0/13/2]

Values in parentheses indicate standard deviations (SD), and numbers in brackets represent failure modes: adhesive failure (A)/mixed failure (M)/cohesive failure within the substrate (C).

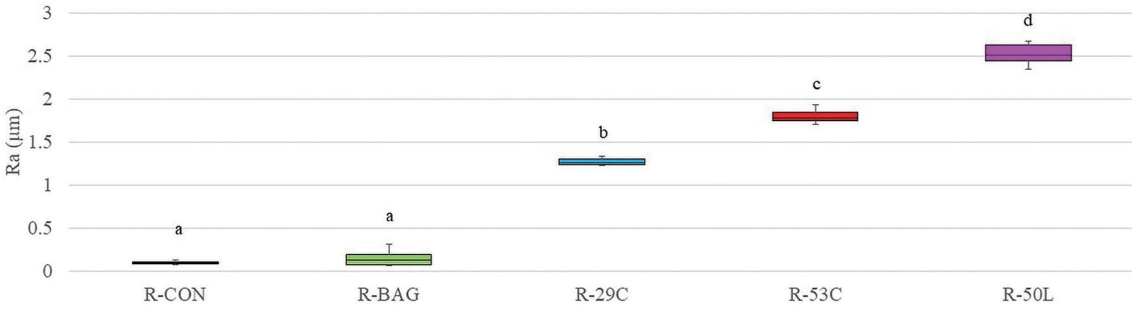

Fig. 1 Surface roughness of resin composites after pretreatments.
The same letters indicate non-significantly different combinations ($p>0.05$).

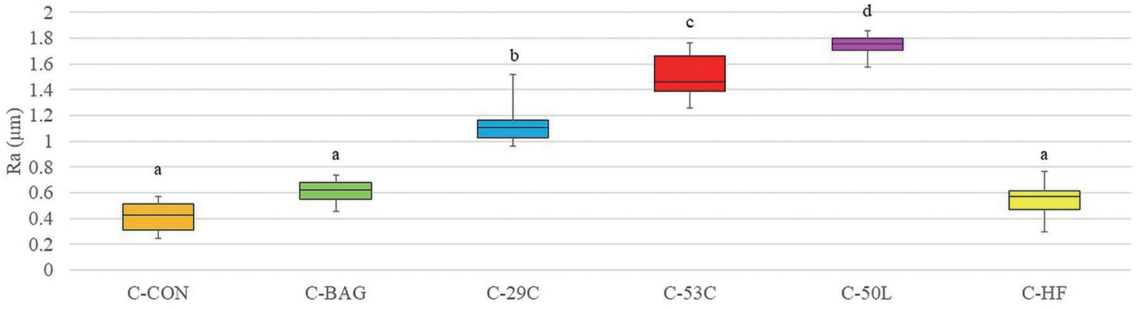

Fig. 2 Surface roughness of glass ceramics after pretreatments.
The same letters indicate non-significantly different combinations ($p>0.05$).

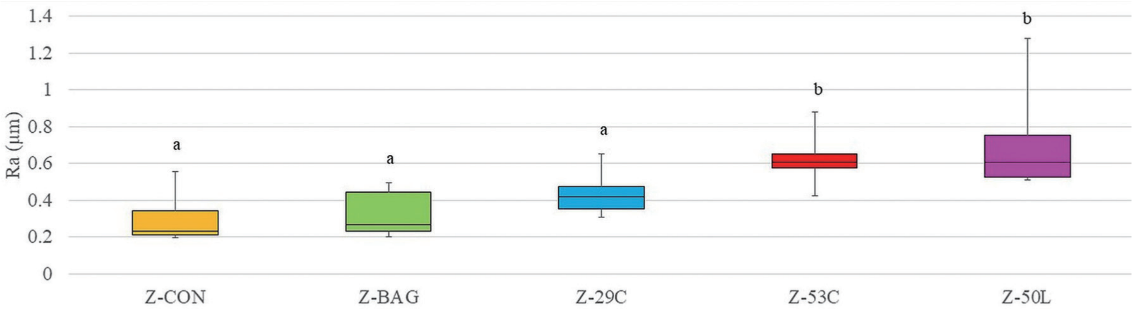

Fig. 3 Surface roughness of zirconia after pretreatments.
The same letters indicate non-significantly different combinations ($p>0.05$).

composites, glass ceramics, and zirconia, respectively. For the resin composites, polishing scratches produced by #600 abrasive paper were observed in R-CON and R-BAG, whereas rougher surfaces were obtained under the other conditions. A similar trend was observed for the glass ceramics. In C-HF, the polishing scratches were removed by HF etching, allowing the underlying microstructure to be clearly observed. For the zirconia, polishing scratches were also found in Z-CON and Z-BAG, while rougher surfaces were obtained in the other groups.

SBS

Figure 7 shows the SBS of the resin composite group, and post-hoc power analysis indicated a high statistical power of 1.000. R-50L exhibited the highest value (19.35 MPa). No significant difference was observed between R-CON and R-BAG ($p>0.05$), whereas the other groups showed significantly higher values ($p<0.05$). Figure 8 presents the results of the glass ceramics group, and C-HF demonstrated the highest SBS (36.72 MPa). However, no significant differences were found between C-CON, C-53C, and C-50L ($p>0.05$). Figure 9 shows the results of the zirconia group, and Z-50L showed the highest value (23.26 MPa). While no significant differences were observed between Z-50L and the other four blast-treated groups, Z-CON exhibited significantly lower bond strength than all other groups ($p<0.05$).

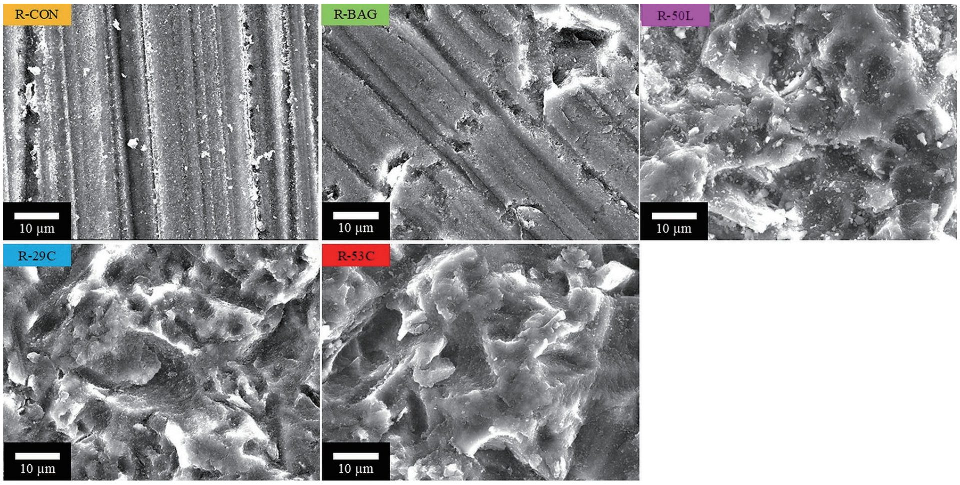

Fig. 4 SEM images of resin composites after pretreatments.
The scale bar represents 10 µm.

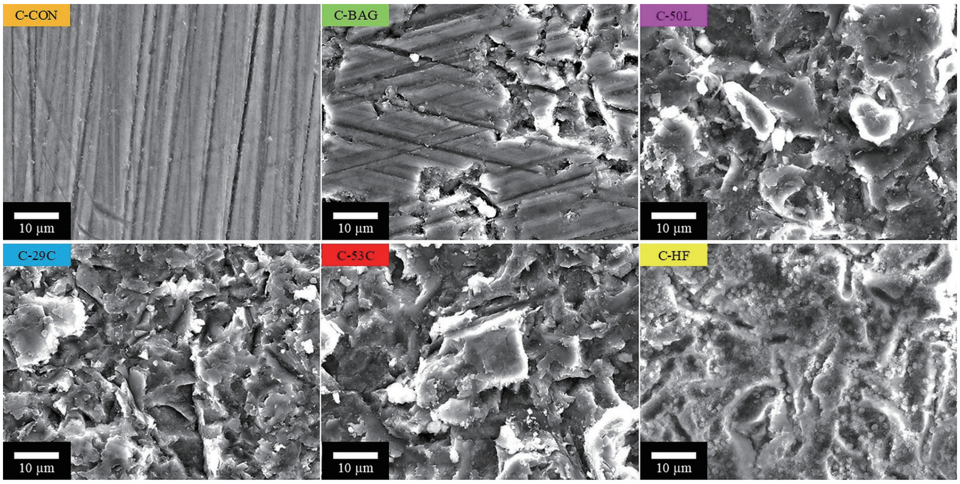

Fig. 5 SEM images of glass ceramics after pretreatments.
The scale bar represents 10 µm.

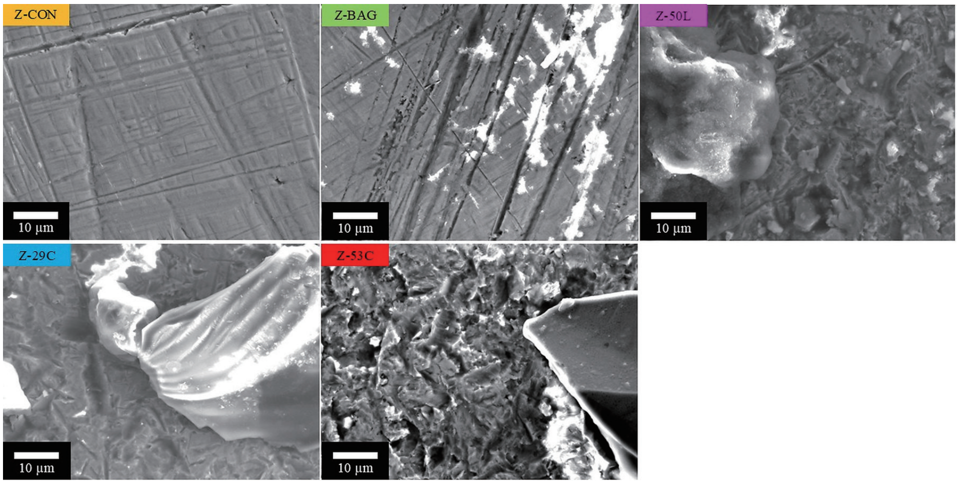

Fig. 6 SEM images of zirconia after pretreatments.
The scale bar represents 10 µm.

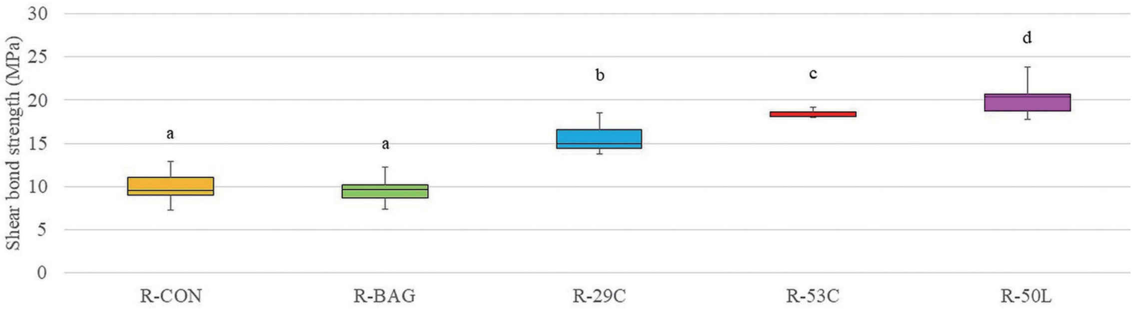

Fig. 7 Shear bond strength of resin composites under different pretreatment conditions. The same letters indicate non-significantly different combinations (p>0.05).

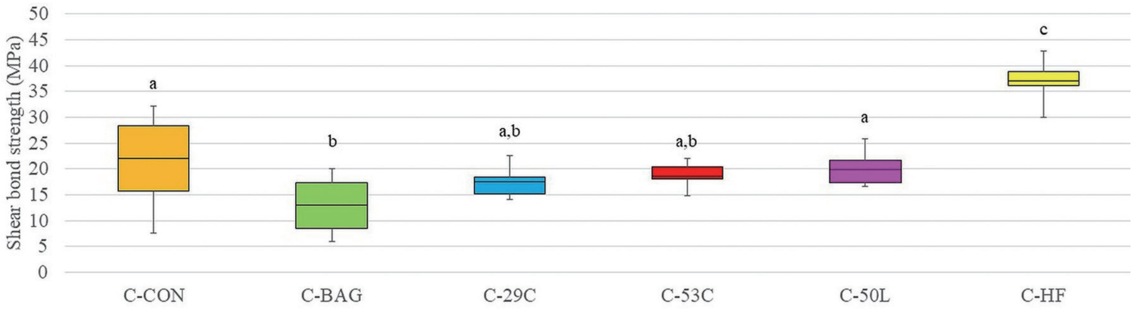

Fig. 8 Shear bond strength of glass ceramics under different pretreatment conditions. The same letters indicate non-significantly different combinations (p>0.05).

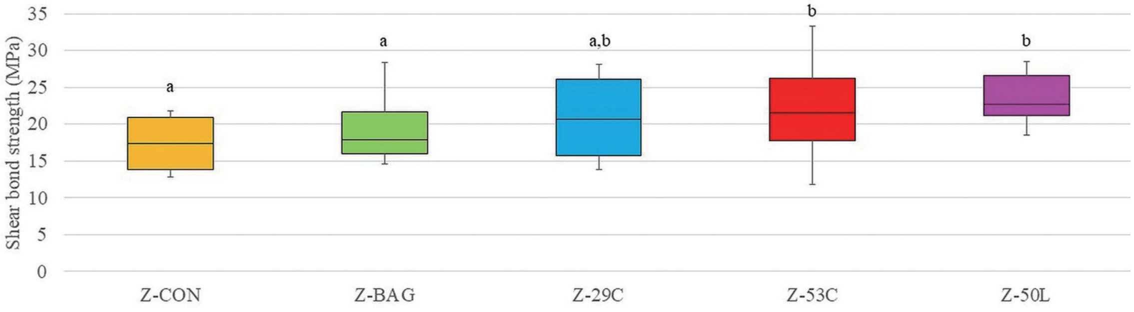

Fig. 9 Shear bond strength of zirconia under different pretreatment conditions. The same letters indicate non-significantly different combinations (p>0.05).

Failure modes

The number of specimens for each failure mode is listed in Table 4. In the resin composite group, adhesive failure was observed in 6.67% of specimens in the R-BAG and R-53C groups. Mixed failure was observed in 86.67% of R-CON, 73.33% of R-BAG, 100% of R-29C, 73.33% of R-53C, and 86.67% of R-50L specimens. The remaining specimens exhibited cohesive failure within the substrate. In the glass ceramics group, mixed failure was observed in 80% of C-CON, 60% of C-BAG, 60% of C-29C, 73.33% of C-53C, 60% of C-50L, and 40% of C-HF specimens. The remaining specimens showed cohesive failure within the substrate. In the zirconia group, mixed failure was found in 93.33% of Z-CON, 86.67% of Z-BAG, 80% of Z-29C, 80% of Z-53C, and 86.67% of Z-50L specimens. The remaining specimens showed cohesive failure.

DISCUSSION

This study investigated the effects of differences between the two surface-pretreatment devices, air abrasion and sandblasting, on the surface roughness and bond strength of three CAD-CAM materials: resin composite, glass ceramics, and zirconia. Comparisons were made between pretreatments performed using a chairside air abrasion device and those using a conventional laboratory sandblasting device. Consequently, the null hypothesis was rejected, as significant differences were found between the conditions for all materials.

Previous studies have reported that alumina sandblasting enhances bonding to CAD-CAM materials[6,12,29,40-42]. Therefore, this study focused on evaluating whether air abrasion devices can serve as a viable clinical alternative to laboratory sandblasting devices for pretreating prostheses before cementation. The air abrasion device used in this study is typically applied for caries removal and surface roughening using alumina particles. It also allows the use of bioactive glass powder, which is indicated for tooth surface cleaning and polishing[35,36,43]. Given its clinical versatility and reduced aerosol dispersion due to water injection, chairside air abrasion is expected to gain broader acceptance in dental practice. Accordingly, the current findings may support its clinical application for pretreating prosthetic surfaces. For the air abrasion parameters set in this study, the pressure was standardized at 0.3 MPa for 10 s at a distance of 10 mm, based on a previous protocol for resin composites[44]. However, because pressure may affect surface roughness, different parameters should be investigated in future studies.

In the resin composite group, both bond strength and surface roughness increased with the particle size of alumina used. However, this trend was not observed with bioactive glass powder, likely due to its inferior abrasive capacity despite its particle size. SEM images confirmed the presence of surface texturing in alumina-treated specimens, which was lacking in bioactive glass-treated ones. There were no significant differences in bond strength between the air abrasion and sandblasting device groups when the same particle size (50 μm) of alumina was used. This suggests that air abrasion with 50 μm alumina achieves similar micromechanical interlocking as laboratory sandblasting device. Fractographic analysis showed cohesive failure within the resin composite blocks in the R-53C and R-50L groups, indicating that the SBS achieved was sufficient to exceed the internal strength of the material. These findings align with those of Stawarczyk *et al.*[21], who reported improved bonding performance for polymer-based CAD-CAM blocks following air abrasion, and with subsequent studies showing enhanced tensile strength of resin luting agents after air abrasion pretreatment[6].

In the glass ceramics group, surface roughness generally increased with the particle size of alumina, while bioactive glass powder and hydrofluoric acid treatment showed minimal roughness enhancement. However, C-HF showed the highest bond strength, despite having surface roughness similar to that of the control. This is attributed to the selective dissolution of the glassy matrix by hydrofluoric acid, producing a retentive surface topography that enhances micromechanical retention[8,23,24]. SEM observations confirmed the matrix dissolution in the C-HF group and revealed residual alumina particles embedded in the surfaces treated with alumina air abrasion. Nevertheless, no significant differences in bond strength were found between groups treated with alumina particles and the untreated control, suggesting that the type of alumina treatment (air abrasion device vs. sandblasting device) has limited influence on bonding efficacy when used without subsequent chemical conditioning.

In the zirconia group, surface roughness increased with the particle size of alumina. SEM images showed that alumina particles remained on the zirconia surface after both air abrasion and sandblasting, indicating that surface modifications were successfully achieved using either method. Özcan *et al.*[27] reported that alumina air abrasion improves the microtensile bond strength of zirconia, and further studies by Atsu *et al.*[13] and Blatz *et al.*[9] demonstrated that applying an MDP-containing primer with silane significantly enhances SBS to zirconia. Based on these findings, the present study applied an MDP-containing primer after alumina pretreatment, yielding favorable results regardless of the device used.

Across all three CAD-CAM materials, air abrasion using alumina particles—whether applied *via* chairside device or laboratory sandblasting device—produced comparable SBS. The results also demonstrated significant differences in SBS depending on the pretreatment method and abrasive media used for each CAD-CAM material. In contrast, bioactive glass powder did not significantly increase surface roughness or bond strength in any material group. Cleaning with ultrasonic or rotary brushes has traditionally been used to remove adhesion inhibitors such as temporary cements, blood, and plaque. However, adhesion inhibitors that are strongly integrated into the surface may be difficult to remove thoroughly with brushes alone[45]. Air abrasion with bioactive glass powder may be suitable for cleaning the surface without affecting the surface roughness. Moreover, while ineffective for creating retentive surfaces, this abrasive may still be useful for intraoral cleaning applications. For instance, bioactive glass powder has been used to remove contaminants such as saliva or temporary cement without damaging tooth structure[37,38]. Although this *in vitro* study did not assess bonding to tooth surfaces, future investigations should simulate clinical conditions by evaluating the effects of bioactive glass air abrasion on contaminated abutment surfaces. These studies will help clarify its role in enhancing adhesion under realistic clinical scenarios.

The main limitations of this study were that the dynamic oral environment was not considered, such as occlusal load, temperature changes. Besides, in the actual clinical situation, contamination by saliva or other solutions may occur, and the bond strength would be affected. This study tested only one adhesive system and one luting agent, and therefore the generalizability of the results may be limited. Thus, further studies are needed to clarify them.

CONCLUSIONS

Within the limitations of this *in vitro* study, no significant differences in SBS were observed when 50 μm alumina particles were used for air abrasion of the inner surfaces of CAD-CAM resin composites, glass ceramics, and zirconia, compared with the laboratory sandblasting device. These findings suggest that air abrasion devices, which can be used at the chairside, may serve as a practical and clinically feasible alternative to conventional laboratory sandblasting devices for pretreating the intaglio surfaces of CAD-CAM dental prostheses prior to cementation.

CONFLICT OF INTEREST

The authors declare no competing interests.

REFERENCES

1) Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: Current status and future perspectives from 20 years of experience. Dent Mater J 2009; 28: 44-56.
2) de Paula Silveira AC, Chaves SB, Hilgert LA, Ribeiro AP. Marginal and internal fit of CAD-CAM-fabricated composite resin and ceramic crowns scanned by 2 intraoral cameras. J Prosthet Dent 2017; 117: 386-392.
3) Beuer F, Schweiger J, Edelhoff D. Digital dentistry: An overview of recent developments for CAD/CAM generated restorations. Br Dent J 2008; 204: 505-511.
4) Mahmood DJH, Braian M, Larsson C, Wennerberg A. Production tolerance of conventional and digital workflow in the manufacturing of glass ceramic crowns. Dent Mater 2019; 35: 486-494.
5) Yoshihara K, Nagaoka N, Maruo Y, Nishigawa G, Irie M, Yoshida Y, *et al*. Sandblasting may damage the surface of composite CAD-CAM blocks. Dent Mater 2017; 33: e124-e135.
6) Stawarczyk B, Basler T, Ender A, Roos M, Ozcan M, Hämmerle C. Effect of surface conditioning with airborne-particle abrasion on the tensile strength of polymeric CAD/CAM crowns luted with self-adhesive and conventional resin cements. J Prosthet Dent 2012; 107: 94-101.
7) Elsaka SE. Bond strength of novel CAD/CAM restorative materials to self-adhesive resin cement: The effect of surface treatments. J Adhes Dent 2014; 16: 531-540.
8) Yoshida K, Kamada K, Atsuta M. Effects of two silane coupling agents, a bonding agent, and thermal cycling on the bond strength of a CAD/CAM composite material cemented with two resin luting agents. J Prosthet Dent 2001; 85: 184-189.
9) Blatz MB, Sadan A, Martin J, Lang B. In vitro evaluation of shear bond strengths of resin to densely-sintered high-purity zirconium-oxide ceramic after long-term storage and thermal cycling. J Prosthet Dent 2004; 91: 356-362.
10) Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: A systematic review. J Prosthet Dent 2007; 98: 389-404.
11) Janda R, Roulet JF, Wulf M, Tiller HJ. A new adhesive technology for all-ceramics. Dent Mater 2003; 19: 567-573.
12) Yun JY, Ha SR, Lee JB, Kim SH. Effect of sandblasting and various metal primers on the shear bond strength of resin cement to Y-TZP ceramic. Dent Mater 2010; 26: 650-658.
13) Atsu SS, Kilicarslan MA, Kucukesmen HC, Aka PS. Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin. J Prosthet Dent 2006; 95: 430-436.
14) Inomata Y, Harada A, Kasahara S, Kusama T, Ozaki A, Katsuda Y, *et al*. Potential complications of CAD/CAM-produced resin composite crowns on molars: A retrospective cohort study over four years. PLoS One 2022; 17: e0266358.
15) Matinlinna JP, Heikkinen T, Ozcan M, Lassila LV, Vallittu PK. Evaluation of resin adhesion to zirconia ceramic using some organosilanes. Dent Mater 2006; 22: 824-831.
16) Souza RO, Valandro LF, Melo RM, Machado JP, Bottino MA, Ozcan M. Air-particle abrasion on zirconia ceramic using different protocols: Effects on biaxial flexural strength after cyclic loading, phase transformation and surface topography. J Mech Behav Biomed Mater 2013; 26: 155-163.
17) Fu L, Engqvist H, Xia W. Glass-ceramics in dentistry: A review. Materials (Basel) 2020; 13: 1049.
18) Okamura S, Takagaki T, Ikeda M, F Burrow M, Nikaido T. Evaluation of bonding performance of a pressure variable chair-side particle abrader. Asian Pac J Dent 2024; 24: 1-4.
19) Azevedo VLB, de Castro EF, Bonvent JJ, de Andrade OS, Nascimento FD, Giannini M, *et al*. Surface treatments on CAD/CAM glass-ceramics: Influence on roughness, topography, and bond strength. J Esthet Restor Dent 2021; 33: 739-749.
20) Borges GA, Sophr AM, de Goes MF, Sobrinho LC, Chan DC. Effect of etching and airborne particle abrasion on the microstructure of different dental ceramics. J Prosthet Dent 2003; 89: 479-488.
21) Stawarczyk B, Trottmann A, Hämmerle CH, Özcan M. Adhesion of veneering resins to polymethylmethacrylate-based CAD/CAM polymers after various surface conditioning methods. Acta Odontol Scand 2013; 71: 1142-1148.
22) Anuntasainont M, Po-Ngam N, Lührs AK, Neoh SP, Pongprueksa P. Fracture resistance of CAD/CAM blocks cemented on dentin using different cementation strategies. J Prosthodont Res 2023; 67: 603-609.
23) Xiaoping L, Dongfeng R, Silikas N. Effect of etching time and resin bond on the flexural strength of IPS e.max Press glass ceramic. Dent Mater 2014; 30: e330-e336.
24) Lyann SK, Takagaki T, Nikaido T, Uo M, Ikeda M, Sadr A, *et al*. Effect of different surface treatments on the tensile bond strength to lithium disilicate glass ceramics. J Adhes Dent 2018; 20: 261-268.
25) Prado M, Prochnow C, Marchionatti AME, Baldissara P, Valandro LF, Wandscher VF. Ceramic surface treatment with a single-component primer: Resin adhesion to glass ceramics. J Adhes Dent 2018; 20: 99-105.
26) Puppin-Rontani J, Sundfeld D, Costa AR, Correr AB, Puppin-Rontani RM, Borges GA, *et al*. Effect of hydrofluoric acid concentration and etching time on bond strength to lithium disilicate glass ceramic. Oper Sent 2017; 42: 606-615.
27) Özcan M, Bernasconi M. Adhesion to zirconia used for dental restorations: A systematic review and meta-analysis. J Adhes Dent 2015; 17: 7-26.
28) Hagino R, Mine A, Aoki-Matsumoto M, Miura J, Yumitate M, Ban S, *et al*. Effect of filler contents on the bond strength of CAD/CAM resin crowns: New resin primer versus conventional silane agents. J Prosthodont Res 2024; 68: 283-289.
29) Lise DP, Van Ende A, De Munck J, Vieira L, Baratieri LN, Van Meerbeek B. Microtensile bond strength of composite cement to novel CAD/CAM materials as a function of surface treatment and aging. Oper Dent 2017; 42: 73-81.
30) Tsukakoshi M, Shinya A, Gomi H, Lassila LV, Vallittu PK, Shinya A. Effects of dental adhesive cement and surface treatment on bond strength and leakage of zirconium oxide ceramics. Dent Mater J 2008; 27: 159-171.
31) Łagodzińska P, Dejak B, Konieczny BJC. The influence of alumina airborne-particle abrasion on the properties of zirconia-based dental ceramics (3Y-TZP). Coatings 2023; 13: 1691.
32) Huang CT, Kim J, Arce C, Lawson NC. Intraoral air abrasion: A review of devices, materials, evidence, and clinical applications in restorative dentistry. Compend Contin Educ Dent 2019 40: 508-513; quiz 14.
33) Mavriqi L, Valente F, Sinjari B, Trubiani O, Caputi S, Traini T. Water-airborne-particle abrasion as a pre-treatment to improve bioadhesion and bond strength of glass-ceramic restorations: From in vitro study to 15-year survival rate.

Materials (Basel) 2021; 14: 4966.

34) Milly H, Austin RS, Thompson I, Banerjee A. In vitro effect of air-abrasion operating parameters on dynamic cutting characteristics of alumina and bio-active glass powders. Oper Dent 2014; 39: 81-89.

35) Banerjee A, Thompson ID, Watson TF. Minimally invasive caries removal using bio-active glass air-abrasion. J Dent 2011; 39: 2-7.

36) Johnson King O, Milly H, Boyes V, Austin R, Festy F, Banerjee A. The effect of air-abrasion on the susceptibility of sound enamel to acid challenge. J Dent 2016; 46: 36-41.

37) Sauro S, Watson T, Moscardó AP, Luzi A, Feitosa VP, Banerjee A. The effect of dentine pre-treatment using bioglass and/or polyacrylic acid on the interfacial characteristics of resin-modified glass ionomer cements. J Dent 2018; 73: 32-39.

38) Paolinelis G, Banerjee A, Watson TF. An in vitro investigation of the effect and retention of bioactive glass air-abrasive on sound and carious dentine. J Dent 2008; 36: 214-218.

39) Lin J, Shinya A, Gomi H, Matinlinna JP, Shinya A. In vitro evaluation of the bonding durability of self-adhesive resin cement to titanium using highly accelerated life test. Dent Mater J 2011; 30: 837-444.

40) Peumans M, Valjakova EB, De Munck J, Mishevska CB, Van Meerbeek B. Bonding effectiveness of luting composites to different CAD/CAM materials. J Adhes Dent 2016; 18: 289-302.

41) Higashi M, Matsumoto M, Kawaguchi A, Miura J, Minamino T, Kabetani T, *et al*. Bonding effectiveness of self-adhesive and conventional-type adhesive resin cements to CAD/CAM resin blocks. Part 1: Effects of sandblasting and silanization. Dent Mater J 2016; 35: 21-28.

42) Kawaguchi A, Matsumoto M, Higashi M, Miura J, Minamino T, Kabetani T, *et al*. Bonding effectiveness of self-adhesive and conventional-type adhesive resin cements to CAD/CAM resin blocks. Part 2: Effect of ultrasonic and acid cleaning. Dent Mater J 2016; 35: 29-36.

43) Sauro S, Watson TF, Thompson I. Dentine desensitization induced by prophylactic and air-polishing procedures: An in vitro dentine permeability and confocal microscopy study. J Dent 2010; 38: 411-422.

44) Lechte C, Hohmann E, Wiegand A, Kanzow P. Effect of different working settings of sandblasting on resin composite repair bond strength. Materials (Basel) 2025; 18: 313.

45) Ding J, Jin Y, Feng S, Chen H, Hou Y, Zhu S. Effect of temporary cements and their removal methods on the bond strength of indirect restoration: A systematic review and meta-analysis. Clin Oral Investig 2023; 27: 15-30.