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Effect of Composite Resin Contamination with Powdered and Unpowdered Latex Gloves on Its Shear Bond Strength to Bovine Dentin

SS Oskoee • EJ Navimipour • M Bahari
AA Ajami • PA Oskoee • NM Abbasi

Clinical Relevance

In order to avoid the negative effect of contamination of composite resins with powdered latex gloves on the bond strength of two-step self-etching adhesive systems, the use of unpowdered latex gloves is recommended with these adhesive systems.

Siavash Savadi Oskoee, MScD, associate professor Dental and Periodontal Research Center, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

Elmira Jafari Navimipour, DDS, MSD, assistant professor, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

*Mahmoud Bahari, MScD, assistant professor, Dental and Periodontal Research Center, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

Amir Ahmad Ajami, MScD, assistant professor, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

Parnian Alizadeh Oskoee, associate professor, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

Nasrin Molla Abbasi, DDS, Department of Operative Dentistry, Dental Faculty, Tabriz University of Medical Sciences, Tabriz, Iran

*Corresponding author: Dental and Periodontal Research Center, Dental Faculty, Tabriz University of Medical Sciences, Golghasht Street, Tabriz, Iran 5166614713; e-mail: bahari.dds@gmail.com

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SUMMARY

The aim of the present study was to evaluate the effect of composite resin contamination with powdered and unpowdered latex gloves on the shear bond strength of etch-and-rinse and two-step self-etch adhesive systems. Standard flat dentin surfaces were prepared on the facial aspect of 120 bovine incisors and randomly assigned into two (n=60) groups: group 1: Single Bond (SB), group 2: Clearfil SE Bond (CSE). Furthermore, each group was randomly subdivided into three (n=20) based on the type of composite contamination (without contamination, contamination with powdered latex gloves, and contamination with unpowdered latex gloves). The adhesives were applied and resin composite bonded to the dentin. After thermocycling, the specimens were subjected to a shear bond strength test. Two-way analysis of variance (ANOVA) and a post hoc Bonferroni test were used for statistical analysis. One-way ANOVA was used to compare shear bond strength values in each group. Statistical

significance was set at $p < 0.02$. Two-way ANOVA showed that the shear bond strength was significantly influenced by the type of composite surface contamination ($p=0.001$). In the SB group there were no significant differences between different surface treatments ($p=0.08$). In the CSE group a significant difference was observed between the subgroup without contamination and the subgroup with powdered latex glove contamination ($p=0.01$); however, no significant differences were observed between the other subgroups.

INTRODUCTION

During the past decade adhesive dentistry has witnessed major advances. Restorative techniques, such as the restoration of various surfaces with composite resins, bonded fixed prostheses, and porcelain laminate veneers have now gained widespread acceptance. Various intraoral and extraoral factors can decrease adhesion properties. Although technique sensitivity has decreased in some instances, adhesive dentistry still requires a clean substrate for proper bonding.[1-4] The adhesion site might be contaminated by saliva, blood, or dental gloves during the procedure, resulting in defective bonding. Improper bonding leads to margin discoloration, recurrent caries, postoperative hypersensitivity, and pulpal irritation.[4-10]

At present, infection control during dental procedures is a major concern. Facial masks, gowns, gloves, and appropriate glasses have been suggested by infection control centers and authorities for infection control.[11] The majority of commercial gloves available are made of latex and are powdered with cornstarch to facilitate wearing and removal of the gloves.[12-14] Unfortunately, some cases of starch side effects during medical and dental procedures have been reported, which include contamination of wounds and development of granulomatous lesions subsequent to surgery.[15-19]

Starch powder particles, which contain latex proteins, can spread by air during wearing or removal of gloves and contaminate the surface of dental equipment, instruments, materials, and the surgical field.[20] The detrimental effects of powdered gloves in clinical dentistry have only been briefly discussed in dental literature.[21,22] Several researchers have reported delay in the setting reaction of polyvinyl siloxane impression materials as a result of contact with these gloves. Delay in the setting reaction might result from the starch itself or the sulfur-containing accelerator particles present in the latex that have penetrated into the starch.[23-27] It has also been reported that contamination of radiographic films with these gloves during processing of the films has a deleterious effect on image quality.[28]

Since the introduction of latex gloves some questions have been raised concerning the effect of this material on resin bonds for restorative procedures, with no consensus in this regard.[29] In some studies the contamination of the bonding surface with gloves has significantly decreased bond strength[29]; however, another study has not been able to demonstrate any significant effect on bond strength.[20] All previous studies on this topic have been carried out with the use of etch-and-rinse adhesive systems.[20,29] Now self-etch adhesive systems have been introduced, which have incorporated etching and priming steps into a single step and have decreased chair time through elimination of the rinsing step with a concomitant decrease in technique sensitivity.[30] In addition, the effect of contamination of bonding surface with latex gloves has been evaluated,[20,29] but the effect of composite resin surface contamination has not been studied.

Therefore, the aim of the present study was to evaluate the effect of contamination of a composite resin surface with powdered and unpowdered latex gloves on shear bond strength of composite resin to bovine tooth dentin with the use of etch-and-rinse and self-etch adhesive systems.

METHODS AND MATERIALS

A total of 120 bovine incisors were used in the present study. The teeth were collected from Tabriz Industrial Slaughterhouse after approval was granted by the Ethics Committee of the Research Deputy of Tabriz University of Medical Sciences. After the removal of any remaining tissues tags from tooth surfaces, the teeth were cleaned with pumice and brush in a low-speed handpiece under constant water spray. Then the teeth were stored in distilled water at 4°C until used for the purpose of the study.

In all the specimens the roots were cut away with a diamond saw in a straight handpiece. Then the facial surfaces of the teeth were abraded with a diamond bur under air/water spray until the superficial layer of dentin was exposed; the dentin surfaces were smoothed with 400-grit and 600-grit abrasive paper to achieve a standard smooth surface. The flat dentin surface was buried inside a plastic syringe filled with self-curing acrylic resin in a manner in which the prepared surface was perpen-

dicular to the horizontal line; the syringe had an inner diameter of 8 mm and had been filled with acrylic resin to a height of 2.5 cm. A total of 120 plastic molds, with a diameter of 3 mm and a height of 2 mm, were prepared for bonding the restorative composite resin to the surface of the samples.

Then the samples were prepared in two groups, as follows, based on the type of the adhesive used.

Group 1: Etch-and-Rinse Adhesive System

In this group, Single Bond (SB) adhesive system (3M ESPE, St Paul, MN, USA) was used. The surface of the samples was etched with 35 wt% of phosphoric acid gel (Scotch Bond Etchant, 3M ESPE) for 15 seconds and rinsed for 15 seconds with water spray; then the surfaces were dried, but not desiccated, for one to two seconds. The SB adhesive was applied to the surfaces in two consecutive layers according to the manufacturer's instructions.

Next, the adhesive was dried with a gentle current of air for two to five seconds and light-cured for 10 seconds at a light intensity of 400 mW/cm^2 at a distance of 1 mm from the surface using the Astralis 7 light-curing unit (Ivoclar Vivadent GmbH, Bremschlstr, Austria). The light intensity of the light-curing unit was checked before the procedure using a Coltolux light meter (Coltene/Whaledent Inc, Cuyahoga Falls, Ohio, USA).

Group 2: Two-Step Self-Etching Adhesive System

In this group, the Clearfil SE Bond (CSE) adhesive system (Kuraray, Okayama, Japan) was used. The surface of the samples was primed for 20 seconds with CSE primer. After application of the bonding, the Astralis 7 light-curing unit was used for the curing process at a light intensity of 400 mW/ cm^2 at a distance of 1 mm.

In the next stage, the samples in each group were randomly subdivided into three groups of 20 based on the surface contamination used:

- Subgroup 1 (control; without contamination): The plastic mold, with a diameter of 3 mm and a height of 2 mm, was placed on the glass slab, filled with composite resin (Filtek Z 250, 3M ESPE), and then placed on the bonding surface. A dental explorer was used to remove excess material. The mold was cured for 40 seconds at a light intensity of 400 mW/ cm^2. The plastic mold was cut away with a no. 11 scalpel blade.
- Subgroup 2 (contamination with powdered latex gloves): In this group, composite resin was packed into the plastic mold on the glass slab. Then its surface was contaminated for two minutes with the outer surface of powdered latex gloves (Supermax Glove Manufacturing, Selangor, Malaysia) in a dark room to prevent composite resin polymerization. The contaminated surface of composite resin was bonded to the tooth structure. One new glove piece was used for each specimen. The remaining steps were similar to those described for subgroup 1.
- Subgroup 3 (contamination with unpowdered latex gloves): All the steps were similar to those described for subgroup 2 except for the fact that the surface of composite resin was contaminated with unpowdered latex gloves (Supermax Glove Manufacturing).

All the specimens were stored in distilled water at 37°C in an incubator until the shear bond strength test. Table 1 summarizes the composition of the materials used in the present study.

Once all the samples were ready, they underwent a thermocycling procedure consisting of 500 cycles between 55°C ± 2°C and 5°C ± 2°C with a dwell time of 30 seconds and a transfer time of 15 seconds to closely simulate the oral cavity conditions before the shear bond strength test.

Finally, all the samples underwent a shearing force with a knife-edge crosshead at 0.5-cm^2 surface area in a universal testing machine (H5K-S Model, Hounsfield Test Equipment, Surrey, England); the strain rate was 0.5 mm/min. The force was applied at the composite cylinder-tooth interface. The maximum force at failure was recorded in newtons, then converted to megapascals by subdividing it to bonding surface area.

The specimens were evaluated under a stereomicroscope (SMZ800, Nikon, Tokyo, Japan) at 20× for failure mode. Failure modes were classified as cohesive (failure inside the composite resin), adhesive (at the interface of tooth-composite resin), and mixed failure (when more than 25% of the failure was adhesive[31]) (Figure 1).

To observe the surface contaminations on the surface of various latex gloves and also the clean and contaminated composite resin surfaces, two samples measuring 1×1 cm from each type of latex gloves and two samples from each type of clean and contaminated composite resins with powdered and unpowdered latex gloves were prepared; these samples were similar in size to the cylinders used

Table 1: *The Materials Used in the Present Study*

Batch Numbers	Manufacturer	Description & Composition	Material
N202942	3M ESPE, St Paul, MN, USA	35 wt% phosphoric acid gel	Scotch Bond Etchant
N202333	3M ESPE, St Paul, MN, USA	Etch-and-rinse adhesive system contains 2-HEMA, Bis-GMA, dimethacrylates, amines, methacrylate functional copolymer of polyacrylic and polyitaconic acid, ethanol, water	Single Bond
Primer: 01027A, Bond: 01531A	Kuraray, Okayama, Japan	Self-etching adhesive system contains 10-MDP, HEMA, camphorquinone, N,N-diethanol-P-toluidine, Bis-GMA, silanated colloidal silica	Clearfil SE Bond
N142256	3M ESPE, St Paul, MN, USA	Visible-light activated, radiopaque, restorative composite; filler is zirconia/silica; filler loading is 60% by volume (without silane treatment), with a particle size range of 0.01 to 3.5 μm; contains Bis-GMA, UDMA, and Bis-EMA resins	Filtek Z250
30235616	Supermax Glove Manufacturing, Selangor, Malaysia	Natural rubber latex + cornstarch	Supermax powdered glove
S3322679	Supermax Glove Manufacturing, Selangor, Malaysia	Natural rubber latex	Supermax unpowdered glove

Abbreviations: Bis-EMA, ethoxylated bisphenol A glycol dimethacrylate; Bis-GMA, bisphenol A diglycidyl ether dimethacryalate; HEMA, hydrosyethyl methacrylate; 10-MDP, 10-methacryloyloxydecyl dihydrogen phosphate; UDMA, urethane dimethacrylate.

for bonding. The prepared samples were gold-sputtered and evaluated under a scanning electron microscope (SEM; Vega-II, Tescan sro, Libusinia Trida, Czech Republic) at 1000×.

Subsequent to evaluating the normal distribution of data with the Kolmogorov-Smirnov test and the equality of variances between the groups with the Levene test, two-way analysis of variance (ANOVA) was used for statistical analysis. A post hoc Bonferroni test was used for the two-by-two comparison of the groups. In addition, the statistical significance of differences in bond strength values between the subgroups of each adhesive system was evaluated by one-way ANOVA and a post hoc Bonferroni test. Statistical significance was set at $p < 0.02$.

RESULTS

Table 2 separately shows the descriptive statistics (bond strength values in megapascals) and failure modes for each group and its subgroups. Two-way ANOVA showed that differences in the mean bond strength values based on the type of the adhesive system were not statistically significant ($p=0.42$). However, the shear bond strength values were significantly under the influence of surface contamination ($p=0.001$). The interaction between the variables of adhesive system type and the type of surface contamination was not statistically significant ($p=0.75$) either. Two-by-two comparison of surface contaminations with a post hoc Bonferroni test demonstrated statistically significant differences between noncontaminated groups and the groups contaminated with powdered latex gloves ($p=0.02$). However, the differences between different surface contaminations were not significant ($p>0.02$).

In comparison of the subgroups based on different surface contaminations in each adhesive group, one-way ANOVA showed that in the SB group there were no significant differences between the subgroups ($p=0.08$). In the CSE group, there were significant differences between the noncontaminated subgroup and the subgroup contaminated with powdered latex gloves ($p=0.01$); however, the differences between other subgroups were not significant ($p=0.13$).

All the failure modes listed in Table 2 were observed in the composite resin structure, and no cohesive failures were observed in tooth structures. Furthermore, in the CSE adhesive system subgroup

contaminated with powdered gloves, cohesive failures were more numerous than the mixed failures.

SEM images of surface contaminations on each type of gloves and composite resin surface are shown in Figure 2.

DISCUSSION

Coincident with the previously noted increase in use of gloves by dental health care workers has been the relatively rapid development of adhesive dentistry. Inadvertent contamination of the surface of composite resin with latex gloves during restorative procedures is a common problem in operative dentistry, which might have a detrimental effect on the shear bond strength of adhesive bonds to dentin.[10,29]

In the present study, the effect of contamination of composite resin with powdered and unpowdered latex gloves on the shear bond strength of SB and CSE adhesives was investigated.

The results of the present study showed that in the SB group no significant differences were observed between the subgroups; however, in the CSE group significant differences were observed between the noncontaminated subgroup and the subgroup contaminated with powdered latex gloves.

In a study carried out by Sanders and others[29] with the etch-and-rinse system ProBond no significant differences were observed in composite bond strength to enamel between groups contaminated with powdered latex gloves and groups contaminated with unpowdered latex gloves, which is consistent with the results of the present study in the SB group. In that study[29] the adhesive system itself had been directly contaminated and enamel surface bonding had been evaluated, but in the present study the surface of composite resin was contaminated after curing the adhesive system. In addition, the results of a study by Roberts and Bartoloni[20] showed that the bond strength of dentin surfaces contaminated with powdered and unpowdered latex gloves, whether before etching or after the application of etch-and-rinse system Excite and before placement of composite resin, had no significant differences with those of the control group (not contaminated with latex gloves). During evaluation with unaided eyes it was observed that contamination of the dentin surface with latex gloves results in the removal of a considerable portion of the air-inhibited resin layer.[20] This removed resin layer was visible on finger tips and on the latex gloves; the surface of dentin had lost a large part of its glossy appearance,

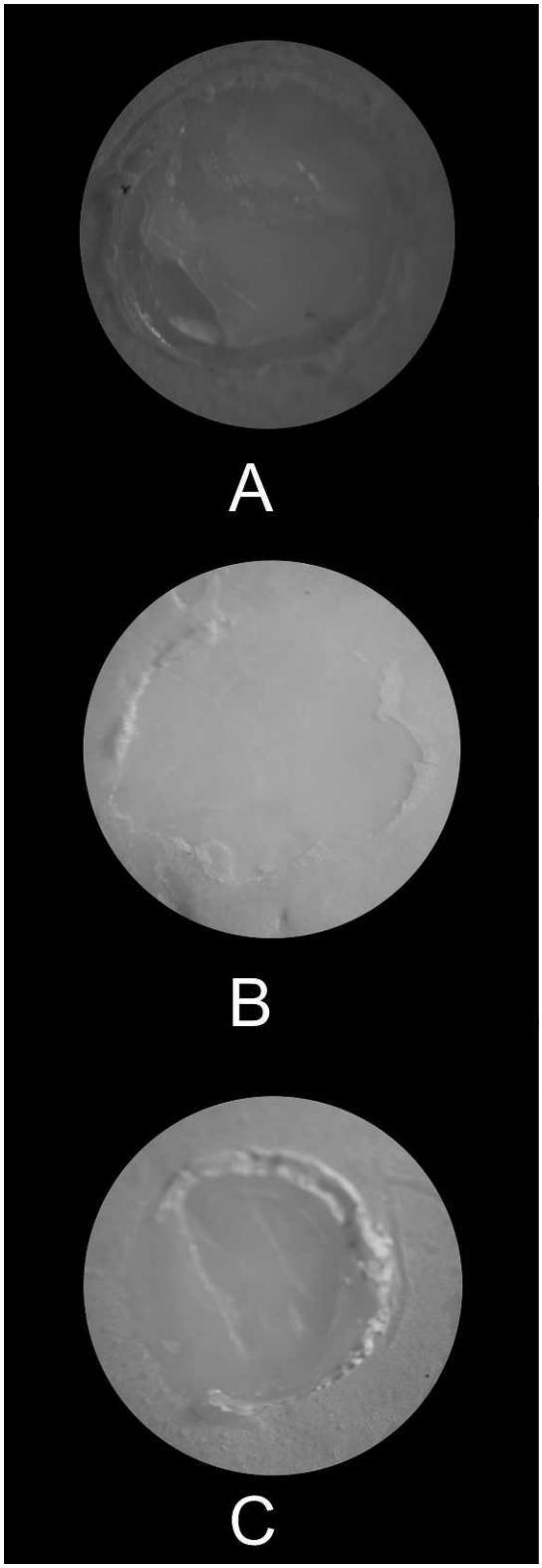

Figure 1. *Different types of failure modes. (A): Cohesive. (B): Adhesive. (C): Mixed.*

Table 2: *Means, Standard Deviations and Standard Error of Shear Bond Strength Values (MPa) and Failure Modes (%)*

Adhesive System	Contaminations	Bond Strength (MPa)			Failure Type, n (%)		
		Mean	SD	Standard Error	Adhesive	Cohesive	Mixed
Single Bond	No contamination	13.55 Aa	4.21	0.94	10 (50)	5 (25)	5 (25)
	Contaminated with powdered glove	9.89 Aa	6.55	1.46	14 (70)	3 (15)	3 (15)
	Contaminated with unpowdered glove	10.33 Aa	5.68	.27	10 (50)	4 (20)	6 (30)
Clearfil SE Bond	No contamination	13.17 Ab	8.16	1.82	13 (65)	4 (20)	3 (15)
	Contaminated with powdered glove	7.98 Ac	3.68	0.82	10 (50)	1 (5)	9 (45)
	Contaminated with unpowdered glove	9.89 Abc	3.99	0.89	11 (55)	3 (15)	6 (35)

Same small capital means no statistically significant differences between adhesive systems.
Same lowercase indicates no statistically significant differences between the subgroups in each adhesive system.

but it was surprising that the bond strength had not decreased significantly.[20]

The lack of contamination influence on the shear bond strength of these fifth-generation adhesives might be attributed to the fact that even in the presence of bonded surface contamination, it is probable that composite resin polymerization reactions are not easily compromised, and even in case of destruction the severity of the problem is not so great as to have a noticeable detrimental effect on composite resin bond strength.

It appears differences in the chemical composition and manipulation characteristics of different adhesive systems play an important role in the effect of contamination on bond strength. CSE belongs to the mild self-etching adhesive systems (pH=1.9) and transmission electron microscope images show that when this adhesive is applied, a shallow 1-μm thick hybrid layer is formed at the resin-dentin interface. The dentin surface is somewhat demineralized and hydroxyapatite crystals are visible inside the hybrid layer; in contrast, when SB is used the hybrid layer is thicker because etching is carried out in one stage and priming/bonding is achieved in the other.[30] Furthermore, according to manufacturer's instructions, SB is applied in two layers, which might be a factor in an increase in the bonding hybrid layer. It appears penetration of starch particles in the oxygen-inhibited layer does not interfere with the SB bonding given the greater thickness of the bonding layer in SB compared with CSE; however, penetration of starch particles in CSE into the depths of the bonding layer contacting the adhesive and dentin can produce defects that are centers for stress concentration, propagating cracks and decreasing bond strength. In addition, it is likely that the presence of starch granules can trap oxygen molecules and prevent polymerization of the adjacent resin layer, increasing the defects. This phenomenon will lead to greater problems if the bonded layer is thin.

In addition, cornstarch in latex gloves cross-links with epichlorohydrin containing not more than 2% magnesium oxide as a dispersive agent. Epichlorohydrin, which renders the cornstarch absorbable, also is used as a solvent for natural and synthetic resins. The presence of any residual epichlorohydrin possibly could account for the decrease in bond strength we observed.[10]

Given the use of two different generations of adhesive systems in the present study and the differences in the results despite identical procedures and contaminations, the chemical interference of epichlorohydrin cross-linked cornstarch powder with polymerization reactions of the adhesive systems used might have had a role in the significant decrease in the bond strength of the CSE adhesive system. Because we did not ascertain the causes of the starch-related adherence problems, we recommend further studies with a wider range of self-etch adhesive systems so that the results can be extended to clinical situations.

Furthermore, evaluation of the effect of contamination with starch particles on the conversion rate of

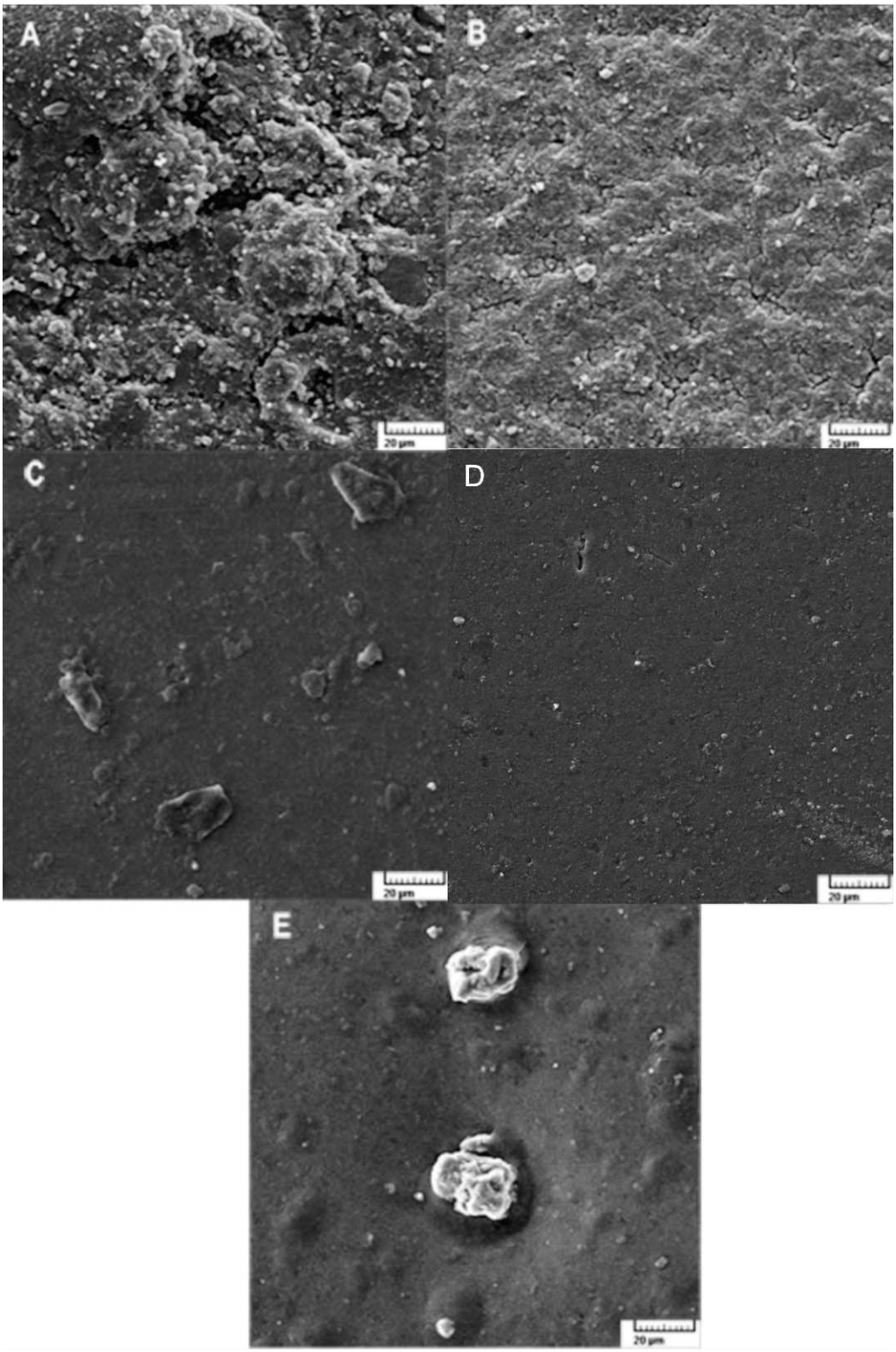

Figure 2. *SEM images of surface contaminations on each type of gloves and composite resin surface. (A): Unpowdered latex glove. (B): Powdered latex glove. (C): Clean composite surface. (D): Composite surface contaminated with unpowdered latex glove. (E): Composite surface contaminated with powdered latex glove.*

composite resins and adhesive systems can help to better understand and analyze the results. In materials that have a low conversion rate, the number of double bonds (C=C) or free radicals is higher; therefore, a higher bond strength is achieved in the presence of starch compared with materials that have a high conversion rate.

The bond failure location provides data about the quality of the bond between the tooth structure and the adhesive. Adhesive failure might be an indication of the wetting ability or the chemical reaction with the dental substrate of the adhesive. In the present study no differences were observed between the percentages of adhesive failures in the CSE and SB groups. In addition, the lower number of adhesive failures, compared with the mixed ones, in the subgroup contaminated with powdered gloves of the CSE adhesive in comparison with other subgroups of the same system might indicate the negative effect of contamination with powdered gloves on bond strength, which is consistent with the results of bond strength analysis.

CONCLUSION

The results of the present study showed that

1. Contamination of composite with powdered and unpowdered latex gloves did not influence the shear bond strength in SB dentin bonding system.
2. Contamination of composite resin with powdered latex gloves decreased the shear bond strength in CSE dentin bonding system.

Conflict of Interest Declaration

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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