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Contamination of resin-matrix composites on chairside handling using latex or nitrile gloves

Ivana Jorge Barros da Cunha

Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

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Trabalho realizado sob a Orientação da Professora Doutora Orlanda Torres
Co-orientador Professor Doutor Júlio Souza

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Resumo

Objetivo: O objetivo deste estudo foi avaliar o efeito de diferentes luvas e condições clínicas na contaminação de incrementos de resina composta durante o procedimento de dentisteria restauradora.

Materiais e métodos: Amostras de resina composta nano-híbrida (*n*=6) foram divididas nos seguintes grupos quanto ao manuseio: (A) espátula clínica; (B) luvas de látex; (C) luvas de látex ou (D) luvas de nitrilo com saliva humana; (E) luvas de látex ou (F) luvas de nitrilo com sangue humano. As amostras foram polimerizadas durante 40 s com um comprimento de onda de 470 nm e intensidade de 400 mW/cm^2. Um grupo de amostras foi envolvido num material bis-acrilico para corte transversal sob papel abrasivo SiC, e analisado por microscopia ótica com ampliações variando de 30x até 500x. Outro grupo de amostras foi preparado para análise por microscopia eletrónica de varrimento com diferentes ampliações variando de 50x até 8000x.

Resultados: A manipulação da resina composta com luvas de nitrilo sem pó ou com espátula clínica evitou a presença de contaminantes. Contudo, a formação de aglomerados de resina levou a um aspeto morfológico heterogéneo. As imagens SEM revelaram a presença de amido de milho proveniente das luvas de látex com pó e a formação de micro-espaços após manuseio. Amostras manipuladas com ambos os tipos de luvas contaminadas com saliva apresentaram uma camada de revestimento composta por rolos de glicoproteínas e cristais de Ca/PO_4. Além disso, os hemoderivados foram transferidos das luvas contaminadas para as amostras de resina composta após manuseio.

Conclusão: As restaurações de resina composta são suscetíveis à contaminação pelos detritos das luvas com pó. Resíduos de saliva ou sangue ficam retidos no interior e na superfície da resina composta durante a manipulação, levando à presença de defeitos, tais como vazios em macro- e microescala ou aglomerados de contaminantes da saliva e sangue.

Palavras-chave: *resina composta, contaminação, saliva, sangue, luvas, manuseio.*

Abstract

Objective: The aim of this study was to evaluate the effect of different gloves and clinical environment on the contamination of resin-matrix composites for restorative dentistry.

Materials and Methods: Nano-hybrid resin composite specimens of resin matrix composite (n=6) were divided in the followed groups regarding the handling with (A) clinical spatula; (B) latex gloves; (C) latex or (D) nitrile gloves with human saliva; (E) latex or (F) nitrile gloves with human blood. Groups of specimens were light-cured under 470 nm wavelength and 400 mW/cm^2 intensity for 40 s. Groups of specimens were embedded in a bis-acryl material for cross-section under SiC grit-papers and then evaluated by optical microscopy at magnification ranging from x30 up to x500. Other specimens were prepared for scanning electron microscopy inspection at different magnification ranging from x50 up to x8000.

Results: Handling of resin-matrix composites with unpowdered nitrile gloves or clinical spatulas avoided the presence of contaminants. However, agglomerates of the resin-matrix composite itself became entrapped leading to a heterogenous morphological aspect. SEM images revealed the presence of corn-based amide released from the powdered gloves. Also, the formation of micro-spaces (voids) occurred after handling with powdered latex gloves. Specimens handled with both type of gloves contaminated with saliva showed a conditioning layer composed of glycoproteins rolls and Ca/PO_4 crystals. Also, blood products were transferred from the contaminated gloves to the resin-matrix composites after handling.

Conclusions: Resin-matrix composite restorations are susceptible to contamination with debris from powdered gloves. Residues from saliva or blood become embedded in the resin-matrix composites during handled leading to the presence of defects such macro- and micro-scale voids or contaminant agglomerates.

Keywords: *resin composite, contamination, saliva, blood, gloves, handling.*

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List of abbreviations and acronyms

BisGMA	Bisphenol A-Diglycidyl Methacrylate
TEGDMA	Triethylene Glycol Dimethacrylate
UDMA	Urethane Dimethacrylate
BISEMA	Ethoxilated Bisphenol A-Diglycidyl Methacrylate
SEM	Scanning electron microscopy
SiC	Silicon carbide
Al_2O_3	Aluminium oxide
EDS	Energy dispersive spectroscopy
SE	Secondary electrons
BSE	Backscattered electrons
OM	Optical microscopic
s	Seconds

1. Introduction

Resin-matrix composites are commonly used in dental practice to directly restore damaged teeth taking into account shape, physicochemical, and esthetic features (1–3). On dental restorations, resin-matrix composites are clinically handled and placed in the damaged tooth site. Clinical guidelines request the use of clean spatulas and gloves to avoid the presence of residues from patient human saliva or blood as well as the environment or other previous materials (4–7). Clinicians often perform a handle manipulation of increments using gloves followed by spatula placement to compact the resin-matrix composites into the damaged teeth site. Such handling procedure increase the risks of contamination of the resin-matrix composites whether the gloves and instruments are not hermetically cleaned. The products from saliva and blood can be embedded in the resin-matrix that affect the physicochemical properties of the material and then the long-term performance of the dental restoration. Also, the presence of pore-like defects or micro-voids into the resin-matrix composite microstructure can occur during handling (4,5,8).

Resin-matrix composites for dental restorations are traditionally composed of a methacrylate-based polymeric matrix involving photo-initiators compounds and silanized inorganic fillers. The organic matrix can be mainly composed of Bisphenol A-Diglycidyl Methacrylate (Bis-GMA) and other methacrylate-based molecules such Triethylene Glycol Dimethacrylate (TEGDMA) and Urethane Dimethacrylate (UDMA) for controlling viscosity and overall physical properties. BisGMA can be replaced by Ethoxilated Bisphenol A-Diglycidyl Methacrylate (BISEMA) considering similarity in molecular mass and physical properties although the viscosity of BISEMA is lower than that recorded for BisGMA (9–11). Additionally, fillers are industrially added in the chemical composition to enhance the physical properties of the composite such as wear resistance, strength, elastic modulus, viscosity, color, radiopacity, translucency, etc (9,10,12).

Commercially available resin-matrix composites reveal a broad range of different size and type of particle-like fillers. The size of filler particles incorporated in the resin matrix has continuously decreased over the years from the traditional to the submicron- and nano-structured composite materials (10,12,13). Thus, a homogenous filler distribution within the organic matrix can be achieved by varying the size of the inorganic particles from micro- to nano-scale dimensions since the small nano fillers are able to occupy the spaces between the larger particles. In this way, the filler content can be increased leading to an enhancement of the mechanical properties of the resin-matrix composites. Also, the decrease in the volume of the organic matrix that cause a decrease in polymerization shrinkage, increase in the degree of conversion of monomers, and a decrease in the material loss on wear (9,13) (2).

Resin-matrix composites have viscoelastic properties that allow the clinician to compact and shape the material into the damaged tooth site prior to their polymerization (1) (8). The restoration technique consists in the compaction of multiple increments with around 2mm-thick on the tooth site to ensure complete polymerization of large restorations and guarantee optimal physical properties. Incremental restoration techniques have also been recommended due to the polymerization shrinkage associated with dental composites (3,14). The light-curing mode varies depending on the clinical case, materials, and clinician skills. However, most of resin-matrix materials used for dental restorations can be polymerized under a wavelength of around 470 nm and 400-600 mW/cm^2 intensity for 40 s. That depends on the photo-initiator (i.e., canforquinone) in the chemical composition of the organic matrix. Although the incremental filling technique is desirable, the longer time required for placement and polymerization of increments also can make contamination control more difficult (14). The major concern in the restoration procedure is related to the risks of contamination when contacting water, saliva, blood, or other materials (8). Also, some clinicians use powdered gloves with amide particles which can be transferred to the resin-matrix composites (14).The presence of defects in the material microstructure such pores and debris negatively affect the mechanical properties of the resin-matrix composites and the long-term clinical success of the restoration (14). A few studies have been performed on adhesives involving contamination of enamel and dentin surfaces although there is a lack of information on contamination between resin-matrix composite increments (14).

2. Objective and Hypothesis

The aim of this study was to evaluate the contamination of resin-matrix composites during clinical handling after contacting powdered gloves, saliva, and blood. It was hypothesized that organic debris and minerals from human saliva or blood are adsorbed on the surface of the resin-matrix composite after handling using latex or nitrile gloves.

3. Materials and Methods

3.1. Preparation of the medium

Human saliva was collected from a single participant with 22 years old. This participant was in good dental and oral health, with no history of antibiotic treatment during the previous 6 months. The participant did not suffer from any systemic or salivary gland disease that could affect salivary secretion. A history of periodontitis or a probing depth more than 6 mm was the exclusion criteria. Saliva was stimulated by neutral chewing gum previously immersed in deionized water for 24 h. During the first minute, the saliva was discarded, then 3 mL was harvested as a source of contamination of the resin-matrix composite specimens (13,14). Also, the human blood was harvested by using a needle-prick to alcohol wiped forefinger at the time of experiment. It has been shown that freshly drawn capillary blood is more suitable in laboratory experiments involving blood contamination than heparinized blood (7).

3.2. Preparation of specimens

This in vitro study involved a completely randomized and blinded design, considering the effect of different contamination conditions of latex or nitrile gloves for clinical procedures used to handle a resin-matrix composite. The following groups were assessed: (A) control group, without handling or contamination, (B) powdered-free nitrile gloves, (C) powdered latex gloves, (D) powdered-free nitrile gloves coated with saliva, (E) powdered latex gloves coated with saliva, (F) powdered-free nitrile gloves coated with human blood, and (G) powdered latex gloves coated with human blood. Fourty two specimens (n=6) were prepared from a light-cured nano-hybrid resin-matrix (Ceram.X SpectraTM ST HV, Dentisply, USA), according to the specifications of each test. Details on the resin-matrix composite are described in Table 1.

***Table 1** - Details of the resin-matrix composites*

Manufacturer	Photoinitiators/ Shade	Fillers	Elastic modulus (GPa)	Flexural strength (MPa)	Organic matrix
Dentsply Sirona, Germany	CQ, A2	78-80 (wt%) 60-62 (v%)	8.5	135	Bis-EMA, UDMA, TEGMA

Powdered disposable latex gloves (Sensitive Latex Gloves RubbergoldTM, Raclac S.A., Portugal) and nitrile gloves (Nitrile DocworldTM, Raclac S.A., Portugal) were used in this study. The specification of the gloves was given by the manufacturer.

In the control group, the resin-matrix composite was removed from the syringe with a Heidmann spatula and placed into the molds without any handling or contamination (4). On the glove contamination, powdered latex glove (group B) or nitrile glove (group C), were removed from its respective pack and immediately used without contamination with human blood or saliva. Specimens of 2 mm-thick were handled for 15 s (on all groups with both gloves) to achieve a round shape for the incremental restoration (4). Gloves contaminated with human blood were used to handle the specimens and then dried carefully with oil-free compressed air for 5 s from a distance of 10 cm. Caution was taking into account to maintain a layer of dry blood on top of the specimens (7). At last, groups of gloves were contaminated with stimulated human saliva and then dried at room temperature (4). Specimens were polymerized using a light-curing unit (Bluestar, Microdont, Brazil) at 400 mW/cm2 for 40 s. The wavelength of the light-curing instrument was set in the range of 450 and 500nm. The light-curing unit was calibrated using a radiometer (ProclinicExpert, Montellano, Lisboa) prior to the polymerization procedure.

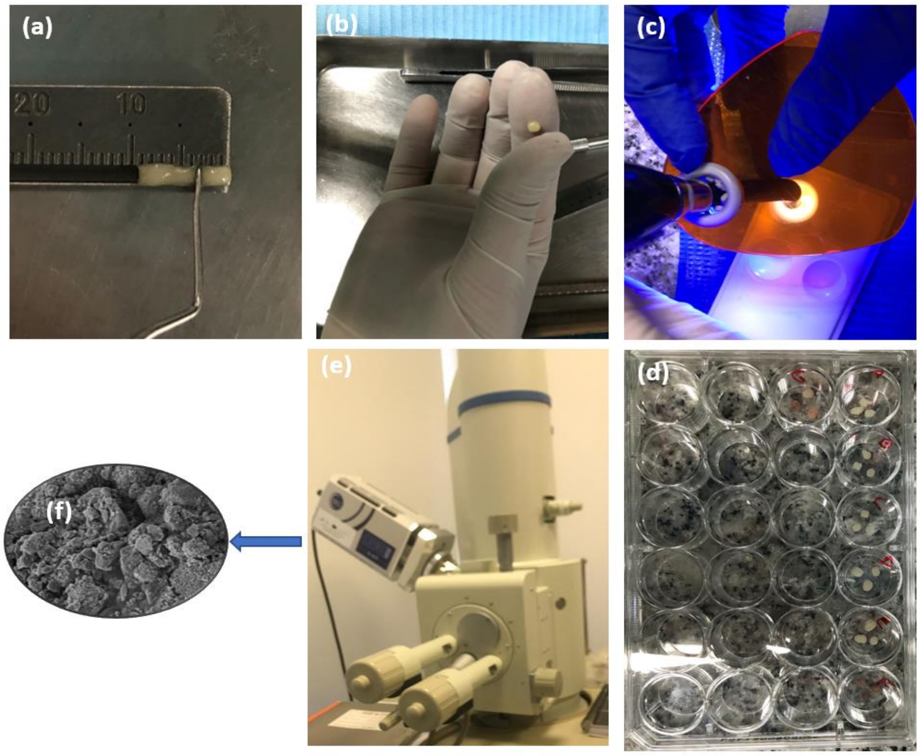

Figure 1 *- Preparation of specimens. (A) Measuring 2mm-thick specimens for (B) handling, (C) light-curing, and (D) storage. (D) Picture of the scanning electron microscopy (SEM) used for the (F) analyses.*

3.3. Scanning electron microscopy (SEM) analysis

Groups of randomly resin-matrix composite specimens were embedded in autopolymerizing polyether modified resin (Technovit 400TM; Kulzer GmbH, Germany) and then cross-sectioned at 90 degrees relative to the plane of the long axis. Surfaces were wet ground down to 2400 Mesh using SiC abrasive papers and then polished with 1μm Al2O3 particles. Surfaces were ultrasonically cleaned in isopropyl alcohol for 10 min and then in distilled water for 10 min. Cross-sectioned specimens were inspected by optical microscopy at magnification ranging from x10 up to x500. Microstructural analyses were performed using an optical microscope (Leica DM 2500 MTM, Leica Microsystems, Germany) connected to a computer to image processing, using Leica Application Suite software (Leica Microsys- tems, Germany). A number of six micrographs were acquired at x500 magnification, for each specimen (n = 18). The software Adobe Photoshop (Adobe Systems Software, Ireland) was used to analyze black and white images, with the black representing the pores and the white the bulk material.

Before SEM analysis, other groups of specimens of each condition were fixed in 2.5% glutaraldehyde for 5 min. Then, specimens were washed three times in distilled water and dehydrated through a series of graded ethanol solutions (50, 60, 70, 80, 90 and 100%). Then the samples were sputter-coated with AgPd thin layer for scanning electron microscopy (SEM) analyses by using SEM unit (JSM-6010 LV, JEOL, Japan) coupled to energy dispersive spectroscopy (EDS). The surface and microstructure of the specimens was evaluated at high magnification ranging from x50 up to x8000 under (SE) secondary and (BSE) backscattered electrons.

4. Results

Optical microscopic (OM) images of the cross-sectioned resin-matrix composites without handling are shown in Figure 2A and B while OM images of the cross-sectioned resin-matrix composites handled with nitrile gloves (free of powder) and powdered latex gloves are shown in Figure 2C-F.

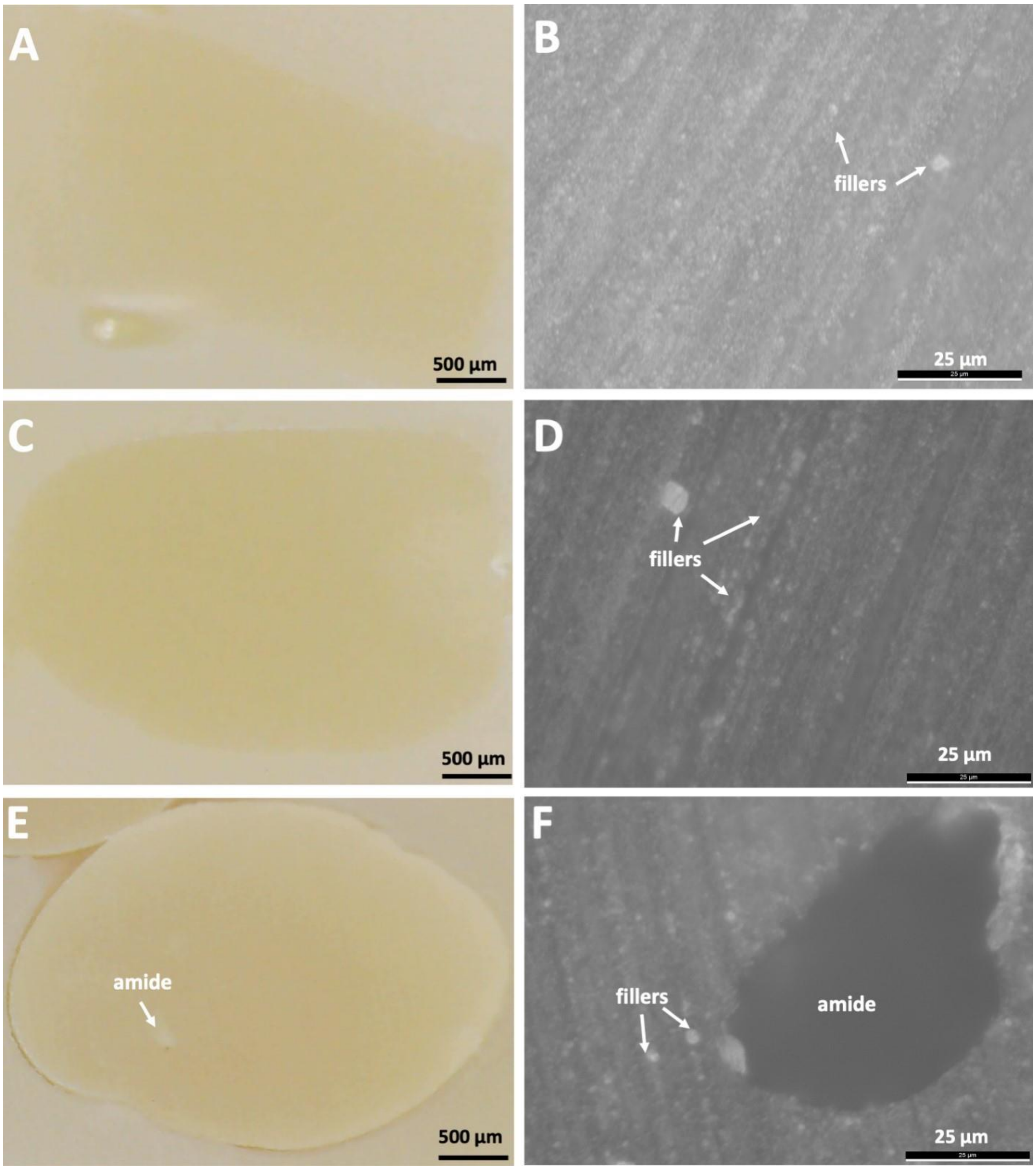

Figure 2 *- Optical microscopy (OM) images of the cross-sectioned resin-matrix composites retrieved from capsules (A,B) without handling, (C,D) after handling using nitrile gloves (free of powder) or (E,F) powdered latex gloves. (A,C,E) OM images at 30x and (B,D,F) at x1000 magnification.*

Optical microscopy images at x30 magnification (Figure 2A, C, and E) showed the morphological aspects of the resin-matrix composites while OM images at x1000 magnification (Figure 2B, D, and F) revealed the micro-scale fillers. As seen in Figure 2E and F, a powder product can be detected in the material handled with powdered latex gloves. The powder product consists of corn amide and its size around 20-30 μm can be confirmed at x1000 magnification (Figure 2F).

Optical microscopic images of the cross-sectioned resin-matrix composites handled with nitrile gloves (free of powder) and powdered latex gloves after contacting human saliva are shown in Figure 3A-D.

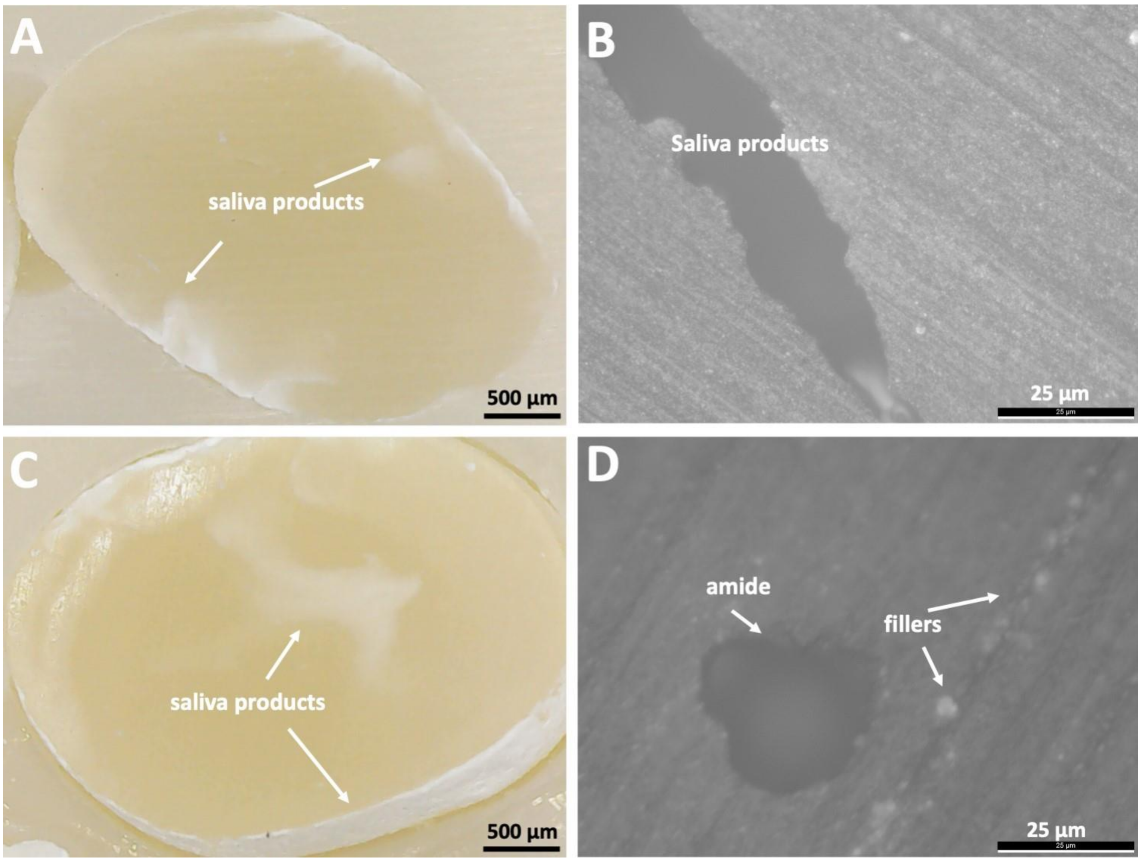

Figure 3 *-Optical microscopy (OM) images of the cross-sectioned resin-matrix composites handled using (A,B) nitrile gloves (free of powder) or (C,FD powdered latex gloves after contacting human saliva. (A,C) OM images at 30x and (B,D) at x1000 magnification.*

Optical microscopy images revealed entrapped saliva products in the resin-matrix composites at x30 or x1000 magnification (Figure 3). As seen in Figure 3C and D, saliva products can be detected in the material handled with nitrile or powdered latex gloves. Considering the dimensions, a potential amide debris can be noted in Figure 3D.

Optical microscopic images of the cross-sectioned resin-matrix composites handled with nitrile gloves (free of powder) and powdered latex gloves after contacting human blood are shown in Figure 4A-D. Optical microscopy images also revealed entrapped blood products in the resin-matrix composites at x30 or x1000 magnification (Figure 4). A detail view of the blood products is shown in Figure 4C and D.

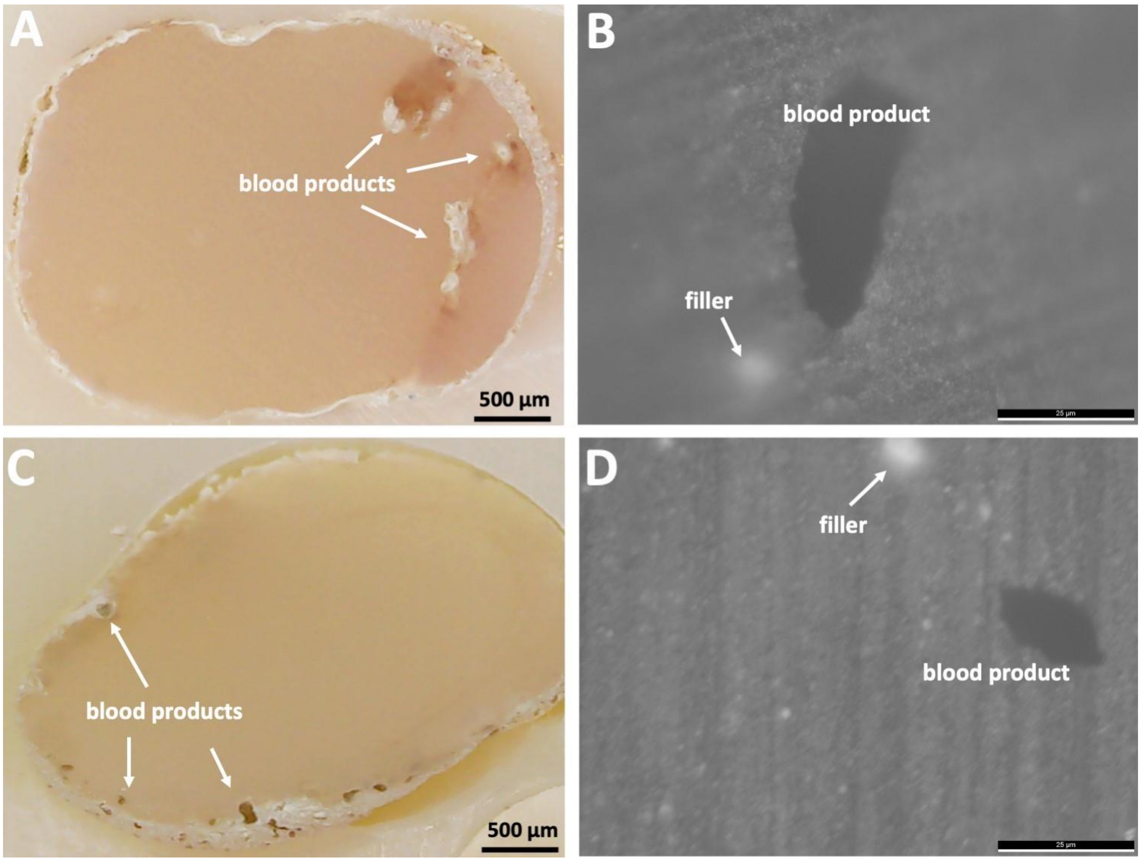

Figure 4 *- Optical microscopy (OM) images of the cross-sectioned resin-matrix composites handled using (A,B) nitrile gloves (free of powder) or (C,F, D powdered latex gloves after contacting human blood. (A,C) OM images at 30x and (B,D) at x1000 magnification.*

SEM images of the resin-matrix composites without handling and handled with nitrile gloves (free of powder) are shown in Figure 5.

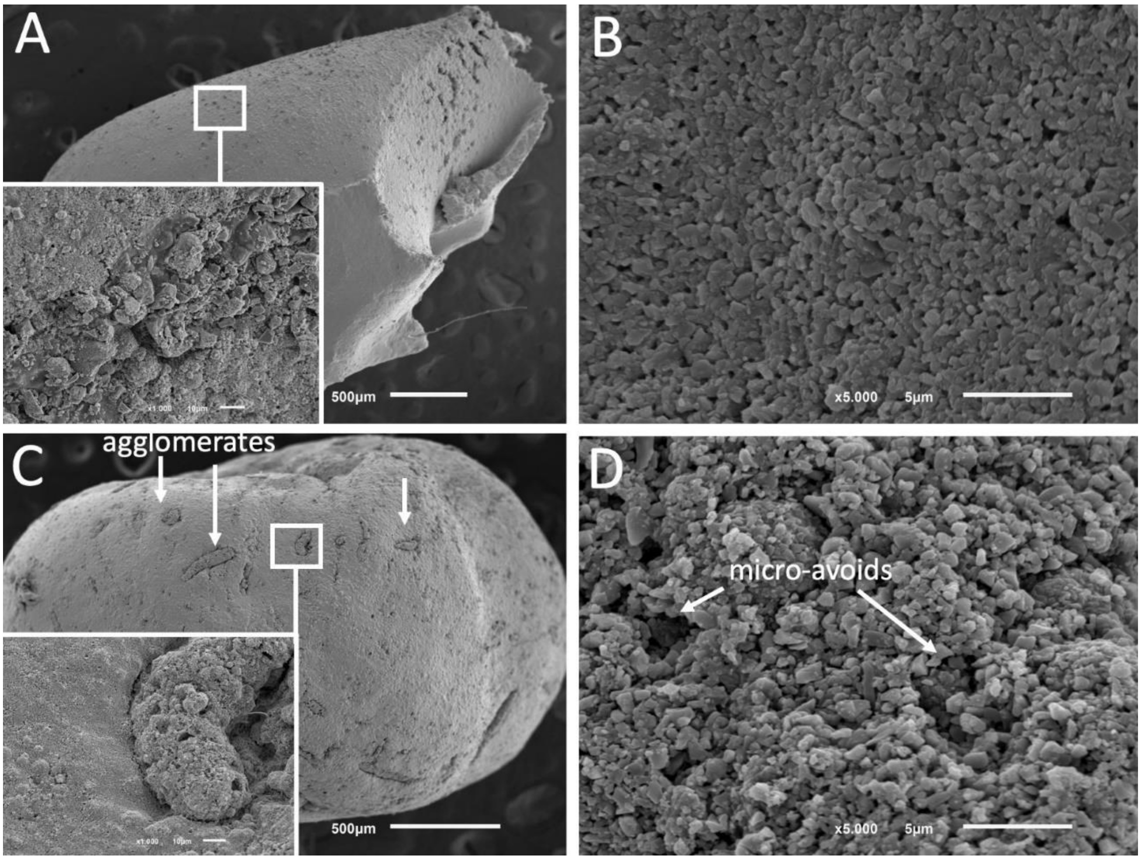

Figure 5 *- SEM images of the resin-matrix composites retrieved from capsules (A,B) without handling and (C,D) after handling using nitrile gloves (free of powder). (A,C) SEM images on SE mode and at 50x and x1000 magnification (zoom in) images. (B,D) SEM images at x5000 magnification.*

SEM images at x50 magnification showed the morphological aspects of the resin-matrix composites. Resin-matrix composites retrieved from the capsules showed irregular morphological aspects from the cutting procedure (Figure 5A) although a compact microstructure can be noticed in Figure 5B. Handling of the resin-matrix composites with nitrile gloves free of powder avoided the presence of contaminants. However, agglomerates of the resin-matrix composite itself became entrapped leading to a heterogenous morphological aspect as seen in Figure 5C. Additionally, micro-spaces (voids) were detected on the resin-matrix composites as seen in Figure 5D.

SEM images of the resin-matrix composites handled with powdered latex gloves are shown in Figure 6.

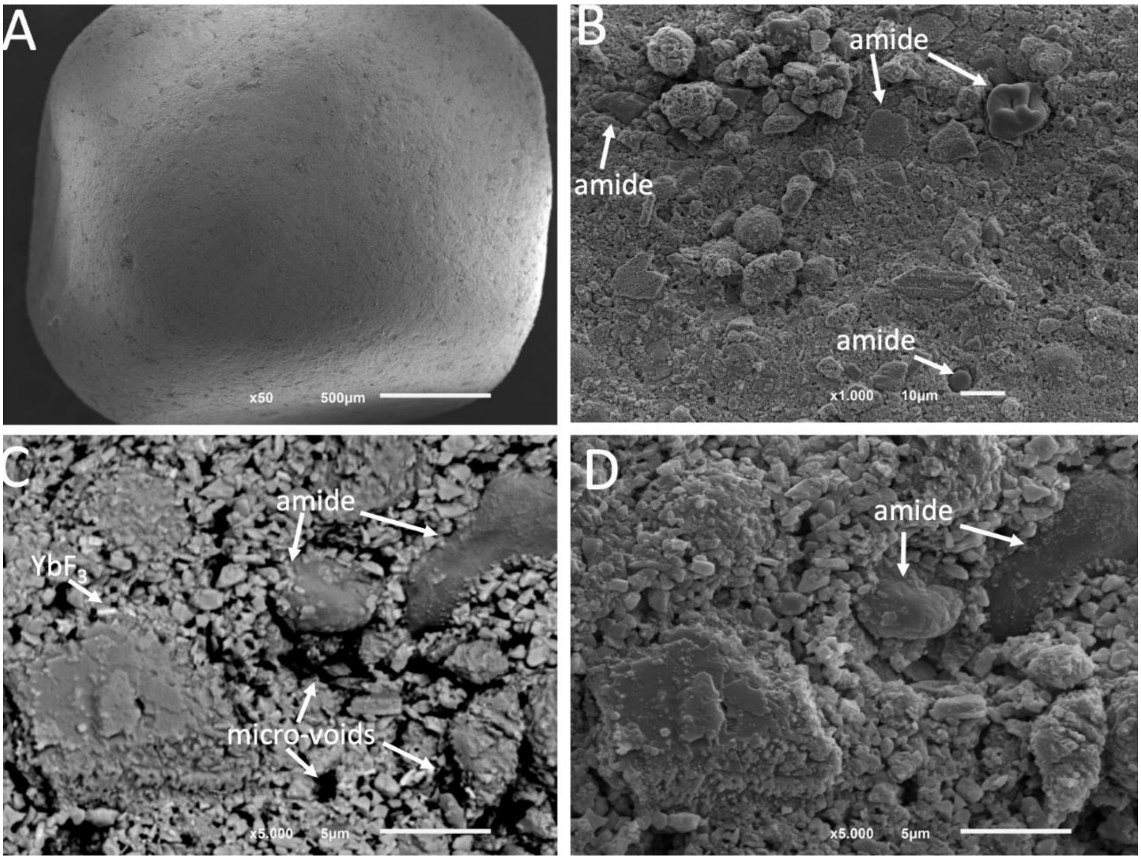

Figure 6 *- SEM imagens of the resin-matrix composites retrieved from capsules and handled with powdered latex gloves. SEM images on SE mode and at (A) 50x and (B) x1000 magnification. (B-D) Presence of corn amide (arrows) from the powdered gloves. (C) SEM on BSE mode showing micro-voids (arrows). (C,D) Images at x5000 magnification.*

As seen in Figure 6, SEM images on secondary electrons (SE) mode at x1000 or x5000 magnification revealed the presence of corn amide (white arrows) released from the powdered gloves. SEM images at back-scattered electrons (BSE) mode (Figure 6C) confirmed the presence of the contaminants (corn amide) and the formation of micro-spaces (voids) after handling.

SEM images of the resin-matrix composites handled with nitrile gloves contaminated with human saliva are shown in Figure 7. A conditioning film of human saliva coated the resin-matrix composites as shown in Figure 7. SEM images on SE mode at x1000 magnification revealed the presence of glycoproteins (Figure 7C) and calcium-based crystals (Figure 7D) from the human saliva. It should be highlighted the formation of glycoproteins rolls due to the handling procedure. Probably, the plastic deformation of the glycoproteins (i.e., mucin) was augmented by the raise of temperature during the friction under handling with gloves.

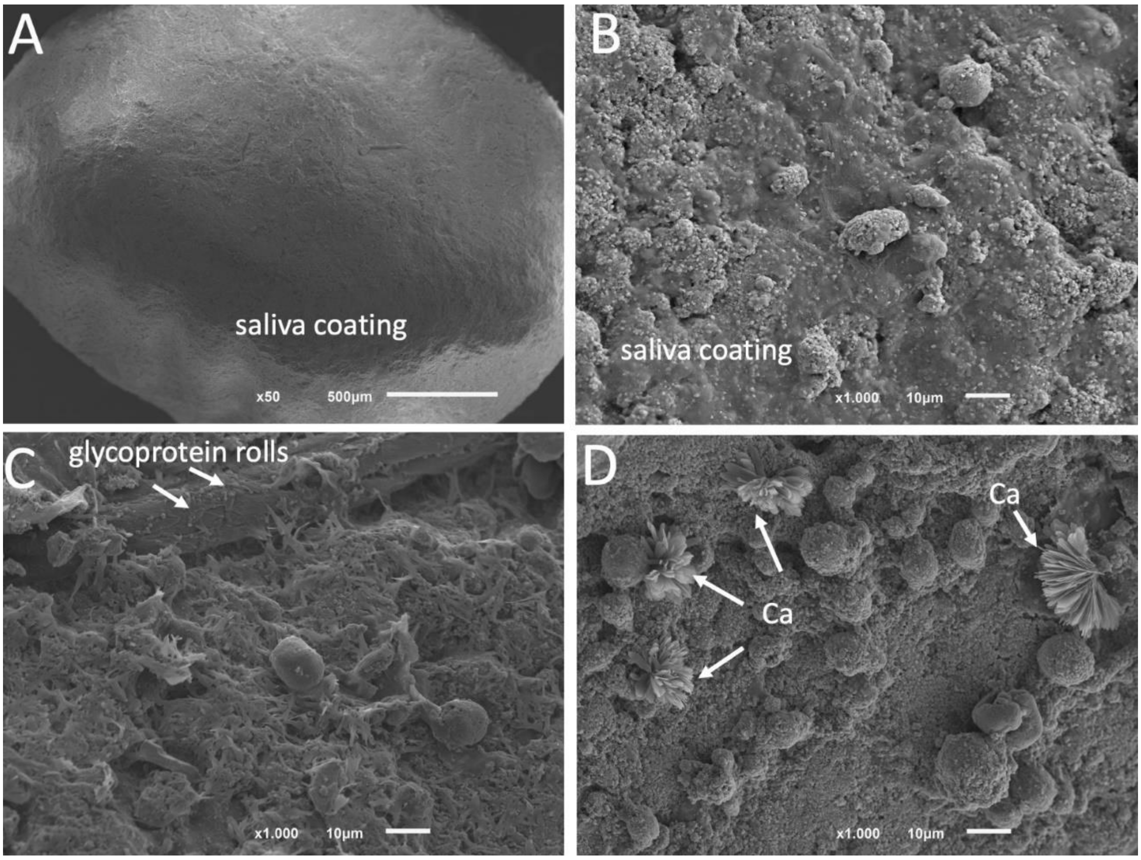

Figure 7 *- SEM imagens of the resin-matrix composites retrieved from capsules and handled with nitrile gloves contaminated with human saliva. SEM Images on SE mode and at (A) 50x and (B-D) x1000 magnification. (B) Saliva conditioning film and (C) formation of glycoproteins rolls (arrows) and (D) calcium crystals (arrows) on the material surface.*

SEM images of the resin-matrix composites handled with nitrile gloves contaminated with human saliva are shown in Figure 8. A conditioning film of human saliva was also detected on the resin-matrix composites (Figure 8). SEM images on SE mode at x1000 magnification revealed the presence of the human saliva coating (Figure 8B and C) as well as the corn amide released from the powdered gloves (Figure 8D).

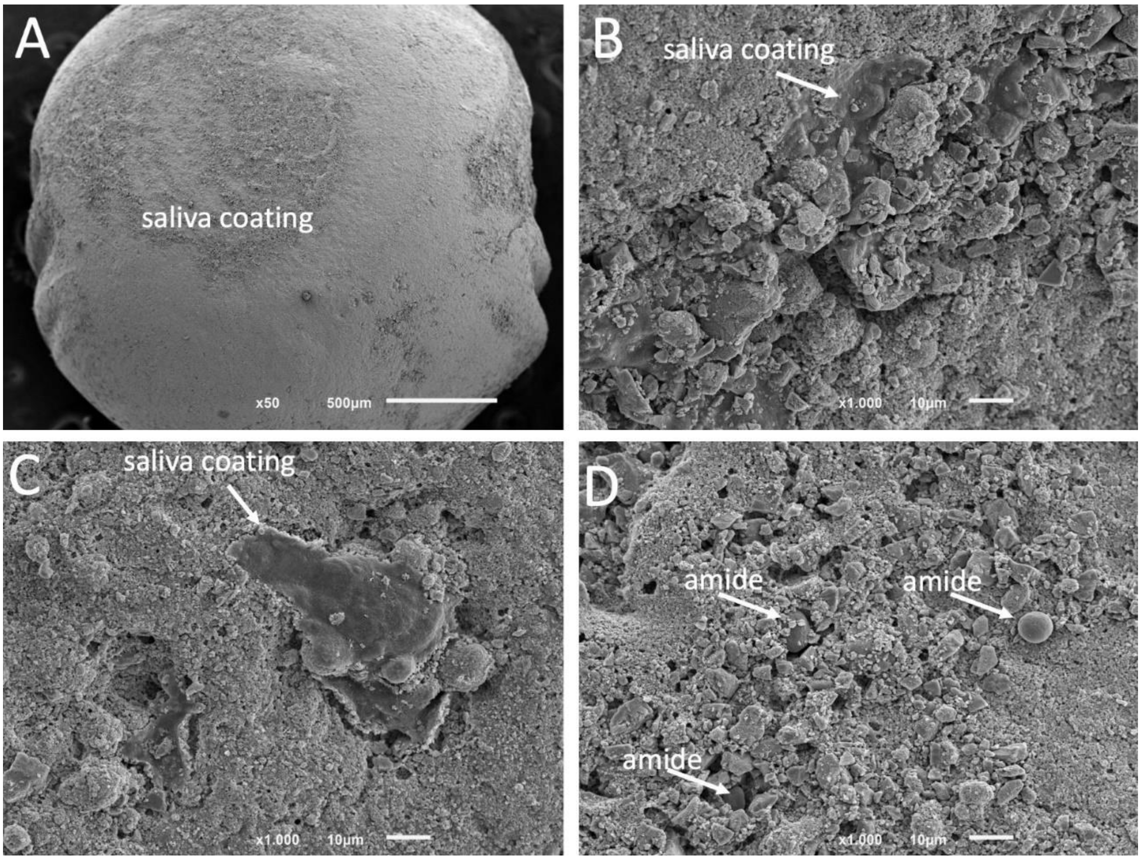

Figure 8 *- SEM imagens of the resin-matrix composites retrieved from capsules and handled with powdered latex gloves contaminated with human saliva. SEM Images on SE mode and at (A) 50x and (B-D) x1000 magnification. (B,C) Saliva conditioning film and (D) the presence of corn amide released from the latex gloves.*

SEM images of the resin-matrix composites handled with nitrile or powdered gloves contaminated with human blood are shown in Figure 9. SEM images at x50 magnification showed irregular morphological aspects of the resin-matrix composites (Figure 9A and C). The presence of glove powder was not detected after handling with nitrile gloves although blood products can be noticed (Figure 9B). SEM images on SE mode at x1000 magnification revealed the presence of blood products coating (Figure 9D-F) and corn amide released from the powdered latex gloves (Figure 9F).

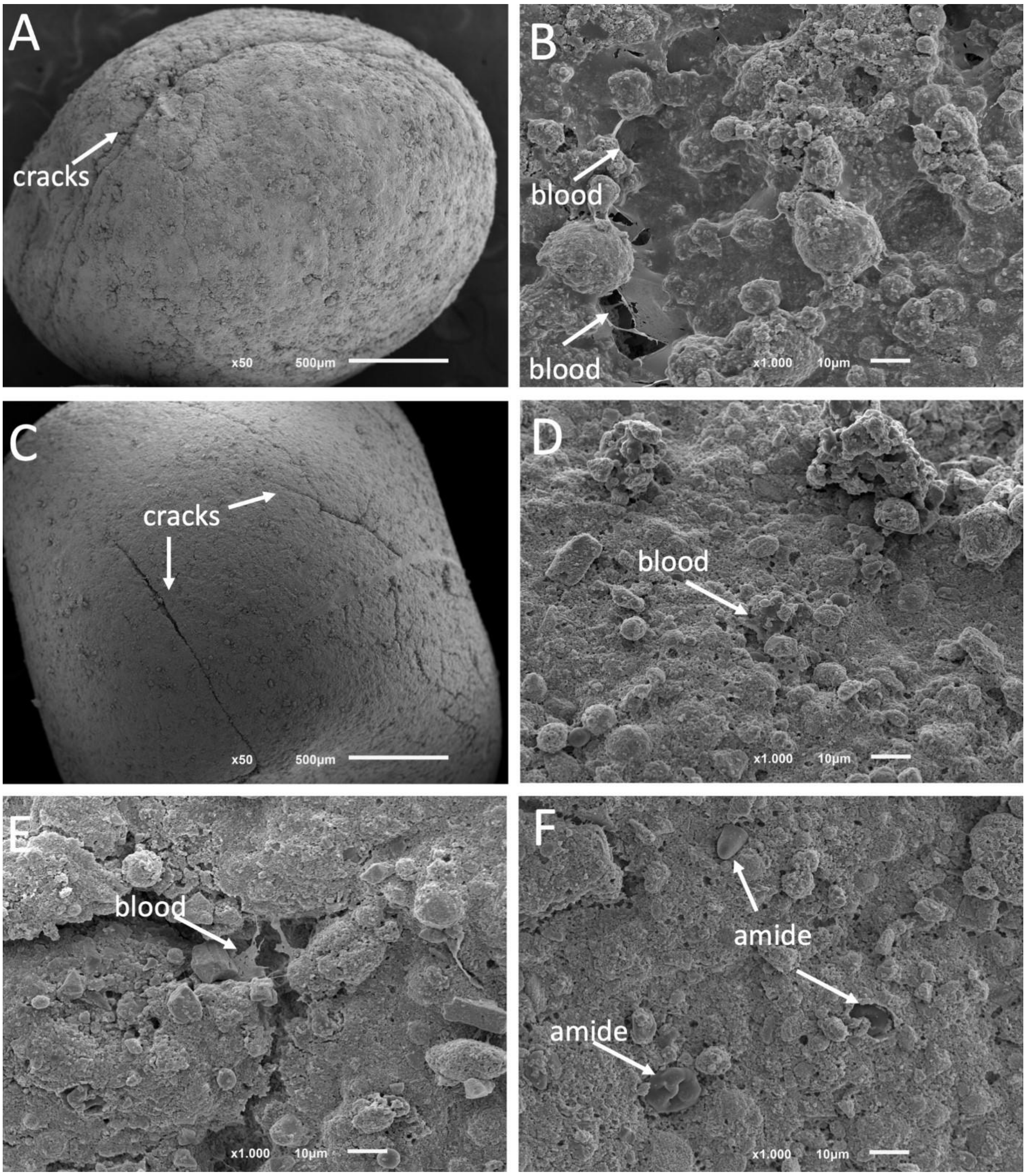

Figure 9 *- SEM imagens of the resin-matrix composites retrieved from capsules and handled using (A,B) nitrile or (C-F) powdered latex gloves contaminated with human blood. SEM Images on SE mode and at (A,C) 50x and (B,D-F) x1000 magnification. (B,D-F) Human blood products covered the surfaces. (D) The presence of corn amide released from the powdered latex gloves.*

5. Discussion

Resin-matrix composites were handled with nitrile and latex powdered gloves contaminated with saliva and blood to simulate clinical conditions. The results of the present study support the hypothesis that debris from gloves as well products from human saliva and blood do adsorb on the surface of the resin-matrix composites during clinical handling. They showed significant differences on the specimens that were handled or not with powdered or unpowdered gloves. Thus, powdered gloves coated with saliva and blood products do alter the surface of the resin-matrix composite. Debris can become entrapped in the microstructure of the resin-matrix composites due to the clinical handling.

In this study, a group of specimens was prepared by using only the Heideman spatula that revealed the absence of debris contaminants) although irregular morphological aspects were noted due to the cutting procedure by the spatula (Figure 2 and 5). However, the spatula can be used to smoothen the surface of the resin-matrix composite increments as recommended by standard clinical guidelines (1,8). The micro-scale inorganic fillers were identified within a size range below 3 μm as also reported in literature (17). Such size of fillers allows the homogenization of the material on handling (18). The absence of debris also occurred on the specimens prepared by handling with nitrile gloves. Even though the handling promoted spherical-shape aspect of the resin-matrix composite increments, agglomerates of the material itself became entrapped on some regions leading to a heterogenous morphological aspect (Figure 2 and 5). Considering the clinical handling can be sensitive to the operator movement, voids, fissures, and pores at macro- and micro-scale can take place into the microstructure of the material as seen in Figure 5. There are some evidences that the technique used for composites placement can directly affect the incorporation of pores and debris in the material microstructure (1,8). Voids, fissures, and pores at macro- and micro-scale can be spots for concentration of stresses and further fracture by cracking propagation under fatigue. Also, those defects are retentive regions for the accumulation of dyes, organic debris, and compounds from dietary and oral cavity leading to the change in the optical properties of the resin-matrix composites (8,19).

The SEM and EDS analyses of specimens handled with latex gloves confirmed the presence of the corn amide (corn starch) entrapped in the microstructure of the resin-matrix composite (Figure 6B). Also, macro- and micro-scale defects were detected as seen in Figure 6C). The presence of debris from the gloves directly decrease the strength of the bulk material and the interface to tooth or resin-matrix composite increments (4,5) (6,14,20). In addition, the presence of corn starch debris can trap oxygen molecules which interfere with the polymerization of the resin-matrix composite increment layer. Corn starch cross-links with epichlorohydrin containing not more than 2% MgO as a dispersive agent. Epichlorohydrin, which renders the corn starch absorbable, also is used as a solvent for natural and synthetic resins. The presence of any residual epichlorohydrin possibly could promote a partial dissolution of the resin-matrix composite increasing the defect size (5).

Then, the contamination with saliva can bring other debris such glycoproteins, minerals, and water, as seen in Figure 7. Saliva is mostly composed of water (99.4%) and the inorganic and organic compounds (0.6%) include proteins, amino acids, glycoprotein (i.e., mucin), Ca2+, K2+, PO4-, and Cl-. In our study, the inorganic compounds were detected by EDS on the specimens surfaces after contact with saliva. On handling the resin-matrix composite, the temperature increases up to at least at 47°C that is enough for the denaturation of proteins (21). Therefore, the handling movement on friction promotes the plastic deformation of glycoproteins forming rolls as seen in Figure 7C. In fact, all those inorganic and organic compounds adsorbed on the surfaces negatively affect the strength of the bulk material and the interface to tooth or resin-matrix composite increments. Some studies have also revealed that conditions of contamination with saliva significantly increased microleakage. The micro- and nano-gaps that result may engender staining, marginal breakdown, hypersensitivity, secondary caries, and the development of pulpal pathology (6,14,20).

On performing dental restorations, blood contamination can also occur even though on thin layer on the gloves. Although the clinicians could visible clean (macro-scale view) the gloves with alcohol, a thin layer at nano-scale of blood products can be enough for the contamination of the resin-matrix composite increments. In this study, the SEM images reveal a complex layer composed of blood products (i.e., red cells and platelets) and corn amide from the gloves. It can also be seen the presence of fissures and voids at macro- and micro-scale. In the Figure 4, it noticed see that blood colored the resin-matrix composite that would influence the esthetic behavior of the restoration. Some studies proved that proteins from blood could impair the adhesion and copolymerization of the resin-matrix composite increments layers leading to failures as previously described in literature (7,22).

6. Conclusion

Within the limitation of this *in vitro* study, the following conclusions can be drawn:

- Clinical handling of the resin-matrix composites provides a heterogeneous surface, with macro- and micro-scale defects such fissures, pores, and voids;
- Organic debris from gloves as well products from human saliva and blood do adsorb on the surface of the resin-matrix composites during clinical handling. The contamination of the material also promote the formation of macro- and micro-scale defects;
- Microscopic examination suggested that blood, saliva, and powder of latex gloves might remain entrapped int the resin-matrix composite microstructure that can affect with the polymerization and adhesion of the resin-matrix composite. In this way, unpowdered gloves are required in the restoration procedure with resin-matrix composites. Also, gloves should be replaced after any potential contamination with saliva or blood;
- Further studies should perform chemical analysis of different brands of gloves before and after contamination and/or cleaning. Also, the contamination of the gloves and spatulas can occur after contacting other restorative materials and therefore a careful cleaning procedure of the spatulas must be performed prior to the restoration.

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