

RESEARCH ARTICLE

Allergic reaction from dental bonding material through nitrile gloves: Clinical case study and glove permeability testing

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Abstract

Objective: This study examines monomer permeation of commercial dental adhesive through nitrile-based gloves, and correlates findings with clinical case studies of dental students having localized skin eruptions following resin placement on a gloved hand to manipulate composite.

Methods: Three dental students self-reported presenting itchy, red skin lesions underneath the area where they placed uncured adhesive resin on a nitrile-gloved hand. Histories and cursory examinations were performed in the Department of Dermatology at The Medical College of Georgia. Infrared spectroscopic methods were used to determine permeation times of known monomer components of commercial adhesive material used through nitrile glove. Monomer permeation times were correlated with the time when the commercial adhesive first applied and penetrated through the glove.

Results: Assessment by the dermatologist concluded that the reporting students had occupational contact dermatitis resulting from components of the adhesive permeating through the barrier glove. Permeation times of neat monomer components of the adhesive resin varied over a wide range, with lower molecular weight showing faster pass-through times. Spectroscopic interpretation indicated that the probable causative agent for the student's skin reaction was 2-hydroxyethyl methacrylate (HEMA).

Conclusions: Probable correlation of the observed skin reaction sites was made with diffusion of HEMA in the uncured dental adhesive formulation through nitrile glove material.

Clinical Significance: All measures to prevent skin contact with uncured methacrylate-based resin components should be taken, including avoidance of resin permeation through a gloved hand. Sensitization to one type of methacrylate can result in sensitization to other types of resins within this family, significantly impacting the careers of both dental auxiliaries as well as clinicians.

KEYWORDS

allergy, dental adhesive, glove permeability, methacrylate, occupational contact dermatitis

1 | CLINICAL CASE STUDIES

Three senior students at the Dental College of Georgia at Augusta University self-reported to faculty having a rash localized to the dorsal surface of one hand, after performing a direct composite restoration. All three students were using school-issued nitrile clinical gloves during the procedures, as required by clinical protocol. Each student developed a pruritic, erythematous plaque in the first dorsal interosseous web space on their non-dominant (left) hand, a few hours after performing composite restorations (Figure 1).

During this type of restorative procedure, each student described applying uncured dentin bonding adhesive material on the gloved area under which the lesions appeared. The reason given for bonding agent application to that location was to lubricate the composite placement instrument while placing and packing uncured paste into the treated cavity, to prevent instrument/composite sticking.

According to each student, the reported incidence was not the first time a lesion had appeared. Each time the lesion location was the same, but the symptom severity and duration increased, when compared with previous incidents. The duration of lesions ranged between 2 and 3 weeks. The area healed with scaling and desquamation over a period of several days and did not recur with avoidance of placing the bonding agent on the glove. The presence and duration of other student cases were similar. All individuals admitted to having seasonal allergies; one student reported a history of asthma and another reported food allergy.

A resident in the Division of Dermatology at The Medical College of Georgia at Augusta University was contacted to examine all affected students, and to provide a clinical diagnosis. In all the cases, an occupational contact dermatitis (OCD), specifically allergic contact dermatitis, a delayed Type IV hypersensitivity reaction, was determined to be the likely diagnosis. The reaction was possibly caused by exposure to the adhesive bonding agent penetrating through the nitrile glove.

After evaluation and diagnosis, students were treated with topical application of an over-the-counter corticosteroid cream. In all three

cases, the rash resolved within 1-3 weeks. Suspecting the bonding agent to be the culprit, all individuals ceased applying the material to the glove and did not report any subsequent issues.

2 | GLOVE PERMEABILITY TESTING

2.1 | Rationale for glove permeability testing

Dental professionals may be at increased risk of developing OCD due to continuous exposure to a large number of sensitizing chemicals, such as methacrylates, that can permeate protective disposable gloves. While these gloves offer good protection against microbes as well as most skin irritants or allergens, small molecular weight acrylates can permeate them quite rapidly. In clinical staff members experiencing skin sensitivity reactions, skin health can deteriorate rapidly, especially when the repeated chemical exposure is combined with the drying effects of regular hand washing and application of alcohol-based hand sanitizer.¹

Methacrylates are a subcategory of acrylic resins.² Dentin-bonding systems contain high concentrations of methacrylates, and many of these monomers are potent sensitizers.^{3,4} A variety of methacrylates are used in the compositions of bonding agents, resin-based composites, and adhesives used in dentistry and medicine.^{5,6} The acrylates and, to a lesser extent, methacrylates (2-hydroxyethyl methacrylate [2-HEMA], triethyleneglycol dimethacrylate [TEGDMA], and 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane [Bis-GMA]) are strong irritants and are notorious allergens.⁷

In response to the prevalence of infectious and contagious diseases, requirements for personal protective equipment by health care providers have escalated; dental gloves are one of these requirements. At first, the vast majority of gloves were fabricated using a latex-based material derived from *Hevea Brasiliensis*, the source of natural rubber.⁸ However, because of the great potential for both patient and operator allergies to natural rubber proteins, the use of non-latex-containing gloves has become preferable. Typically, newer glove types are made of a nitrile-based material, which offers enhanced flexibility and a much lower potential for operator or patient topical reactions. However, like all polymer-based gloves, these items are not impervious. A wide variety of literature exists detailing the porosity of gloves to various organisms as well as fluids. Good clinical practice calls for replacement of disposable nitrile gloves after every 40 minutes of continuous use.^{9,10}

In this study, clinical evidence of allergic dermatitis was observed directly under the glove on which the students were placing the same unpolymerized dentin bonding agent. Given suspected glove permeability of various components in the bonding agent, it was determined to observe the time-based permeability of this uncured dentin bonding agent through the nitrile gloves worn by the students. In this manner, it was hoped that the specific component in the commercial adhesive responsible for initiation of the skin reaction might be identified.



FIGURE 1 Development of an erythematous, well-demarcated thin plaque seen 1 day after application of bonding resin to the gloved area directly above the affected skin

3 | BACKGROUND OF THE PROBLEM

3.1 | Methacrylates in dentistry

Acrylic resin-based polymer materials have been used since the 1960s as direct dental restorations, and their use has increased since the 1990s to replace metallic restorations, such as amalgam.¹¹ A variety of methacrylates are constituents of bonding agents, resin-based composites, and adhesive systems used in dentistry and medicine.¹² Methacrylates are known to quickly permeate most medical gloves, regardless of the glove composition.^{5,6} Also, repeated hand exposure to water, soaps, saliva, dental materials, and disinfecting agents present a constant threat to the integrity of skin as a protective barrier.¹³ Repeated hand-washing may cause skin dryness and chapping, aiding penetration of acrylic monomers into the skin and enhancing the potential for contact dermatitis.¹

3.2 | Wetting instruments on gloved hand to minimize

In many cases, when working with composite material, particularly during highly esthetic procedures, the dental professional lubricates an insertion instrument to facilitate resin composite manipulation,^{14,15} making it easier to insert and sculpt the uncured material into the preparation by reducing its adherence to the insertion instrument.¹⁵ This technique may involve application of an uncured bonding agent to the back of the gloved-hand of the operator or assistant. The uncured adhesive is placed on the hand for easy access and to avoid contamination of the rest of the adhesive.¹⁵ Skin lesions are typically found in areas corresponding to location of the applied adhesive agent (even if wearing protective glove barriers), with an increase in the numbers of such cases occurring in conjunction with the accelerated demand and use of resin-based restorations.¹⁶⁻¹⁸ Dental personnel work daily with uncured methacrylates, and thus face the risk of monomer contamination through gloves as well as placement directly on unprotected skin.

4 | INSTRUMENT/COMPOSITE STICKING

Acrylates and methacrylates are known as strong irritants, but they are also notorious allergens.^{3,4} However, completely polymerized acrylic plastics are considered inert and harmless.⁷ Allergy to dental resin-based materials is an immunologic reaction to unpolymerized substances remaining in the resin matrix (eg, monomers, inhibitors, and stabilizers). Monomers are small molecules that, during the polymerization reaction, are able to covalently bond and form long polymeric chains (the polymer network). The backbone of the molecules varies greatly and can be of aromatic or aliphatic origin, or a combination. Low molecular weight monomers are added to increase the degree of conversion of the resulting polymer, as well as to lower the viscosity of the material during placement and handling.^{19,20} HEMA

and TEGDMA are both common monomers in dental resin materials. Both of these monomers are used as diluent agents, controlling resin viscosity and thereby enhancing the degree of monomer conversion.²¹

5 | PREVALENCE OF THE PROBLEM

In 2009, the Dental Biomaterials Adverse Reaction Unit (BVG) reported an increase in adverse reaction incidences to dental polymer resin-based materials.²² Using that data, it is estimated that, over the last decade, between 4% and 9% of all reactions to dental biomaterials were caused by resin-based materials, with the number of incidences on the rise.^{22,23} A 2012 study considered acrylates to constitute an uncommon, although important, cause of contact dermatitis in general dermatology practices.^{24,25}

5.1 | Skin allergic reactions to methacrylates

After initial sensitization, a Type IV (or delayed-type hypersensitivity reaction) typically occurs 1-2 days following exposure to the specific antigen. The lipid-soluble molecules diffuse through cell membranes, conjugate with proteins, and form complexes of antigens. The antigen-presenting cell of Langerhans binds to the allergen-protein complex and a cellular response takes place, mediated through T-lymphocytes. The amount of antigen required for a Type IV reaction is about 100-1000 times greater than that required for a Type I, IgE-mediated reaction.²⁶⁻²⁸

Currently, there is no specific information about the metabolism of acrylates in human skin. However, dermal exposure to these components has been evaluated in studies examining them in vivo penetration in rodents evaluating uptake, metabolism,^{29,30} and adverse sequelae.³¹ The absorption of acrylates is quite slow. It is very likely that both enzymatic and non-enzymatic pathways play a role in the cutaneous metabolisms of acrylate absorption. Constitutional or temporary alterations of sebaceous secretions result in abnormal cutaneous absorption of acrylates; low sebum secretion increases cutaneous pH, thus reducing the non-enzymatic transformation of acrylates into acrylic acids.

According to previous studies,³² dermatitis is the most frequently diagnosed adverse response³³⁻³⁶ to these types of resins. To develop a contact allergy, an individual must be sensitized to the specific allergen at an earlier occasion. Cross-reaction among methacrylate monomers is common, indicating that a patient or clinician, who has been sensitized to one monomer, will likely react to one of the others³⁷ in a similar manner. This cross-reactivity is of high concern in dentistry—especially in the dental educational and commercial dental laboratory environments. Highly volatile, methacrylate-containing restorative materials are often used in large, open lab areas and can be absorbed through breathing; long-term exposure of students or employees increases the subsequent risks of sensitization with other methacrylate-containing resins, which are ubiquitous in dentistry. Thus, it behooves educational facilities

and dental laboratories to comply with OSHA standards for contact and airborne content of methacrylates.³⁸ At this time, almost all restorative resins are in the methacrylate family. Thus, the potential for adverse reactions will only increase with exposure as alternative substitutes are not currently available.

5.2 | Purpose

The purpose of this study was to identify which component in the commercial bonding agent might be the cause of the students' contact dermatitis. In addition, the permeability rates of known, neat monomers known to be present in this product were analyzed using infrared spectroscopy. The overall object was to correlate the rates of resin permeability of monomer components with that of the commercial product in an attempt to identify which of the monomers was likely the causative agent transiting the glove and causing the skin reactions observed in the students.

5.3 | Hypotheses

Two research hypotheses were developed. The first hypothesis assumed that there will be a significant difference in mean permeation times among the individual monomeric components of a commercial filled dental adhesive resin through nitrile gloves. The second hypothesis considered that there would be no significant difference in the initial glove permeation time of a known monomer component and that of the initial permeation time observed in the dental adhesive.

5.4 | Materials and methods

The diffusion of three neat methacrylate-based monomers (HEMA, Bis-GMA, and Glycerol 1, 3-dimethacrylate [GDMA]), identified as components of a commercial dentin bonding adhesive³⁹ (Optibond FL, Kerr) was tested separately. In addition, permeation time of TEGDMA, a common co-monomer diluent found in many restorative resins, was examined for comparative purposes, although it is not a listed component of the commercial adhesive agent tested. Glove permeation times of the actual commercial adhesive product were also obtained. (Table 1).

Square sections (4 cm × 4 cm) of the same disposable, powderless, blue nitrile medical examination gloves worn by the reporting dental students (Micro-Touch, Ansell Healthcare, Iselin, New Jersey) were cut. The pieces were taped to the surface of a computer-controlled, heated stage (30°C) of a diamond, horizontal attenuated total reflectance (ATR) unit (Golden Gate, SPECAC, Fort Washington, Pennsylvania) in the optical compartment of an infrared spectrometer (FTS-40, Rio-Rad/Digilab, Cambridge, Massachusetts). This temperature was maintained throughout the course of each experimental run, and was selected to mimic that measured using an infrared thermometer (Model 69 465, Cen-Tech Infrared Thermometer, KunShan

TABLE 1 Monomers and commercial dental adhesive tested

Monomer	Chemical name	CAS #	Source
Bis-GMA	Bisphenol A glycidyl methacrylate	1565-94-2	Esstech Inc, Essington, Pennsylvania
GDMA	Glyceryl dimethacrylate	1830-78-0	
TEGDMA	Triethylene glycol dimethacrylate	109-16-0	
HEMA	Hydroxyethyl methacrylate	868-77-9	
	Commercial adhesive bonding agent	Item #	Manufacturer
	Optibond FL: Adhesive	33 352	Kerr Dental Products, Orange, California

Abbreviations: Bis-GMA, 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane; GDMA, glycerol 1, 3-dimethacrylate; HEMA, 2-hydroxyethyl methacrylate; TEGDMA, triethyleneglycol dimethacrylate.

Radiant Innovation Co, Ltd., Kunshan City, China) on the skin surface in the area of interest after wearing a similar nitrile glove for 15 minutes. The center of the cut glove section was coincident with the flat diamond sensor of the ATR unit below it. The cut section was positioned such that it was linearly stretched 10% in each direction, simulating stretching from being worn. This value was obtained by noting the length between two dots on an unworn glove in the area of interest, and then measuring that distance while the glove was worn. The stretched glove was in contact with the heated surface (30°C), for approximately 1.5 minutes prior addition of the monomer to test. Small portions of each neat monomer present in the uncured, commercial adhesive were placed on the center of the top surface of the glove square, a sheet of Mylar placed over top, followed by a thin glass plate (microscope slide). Downward pressure was applied to provide a detectable signal by maintaining the glove flat against the crystal. This pressure was applied to the layers through a vertically driven, flat-ended plate that was lowered using a torque wrench to a predetermined value (40 Ncm torque), providing a reproducible flux differential to the fluids across the glove surface ($n = 5$). Figure 2 provides a diagrammatic depiction of the experimental setup.

Infrared spectra were collected for various time intervals (depending on permeation results) at 1 scan per second using 2 cm^{-1} resolution to obtain a time-based record of the infrared spectrum of the nitrile glove side opposite to which the resins were applied (from 1 to 3 hours). The real-time spectra were imported into spreadsheet format (EXCEL, Microsoft, Redmond, Washington). A custom spreadsheet program was written to plot time-based changes in the nitrile glove spectra where the C=O group ($1710\text{--}1714\text{ cm}^{-1}$), present in all tested materials, first indicated permeation of a methacrylate monomer through the glove. The time at which C=O absorption was first detected was recorded and identified as the permeation time for that experimental run. Mean permeation times were compared statistically

FIGURE 2 Diagram of experimental set showing placement of the stretched nitrile glove, applied resin, and application of a vertical pressure. Fluids diffusing through the glove were detected by their presence on the diamond ATR element directly beneath the glove specimen. ATR, attenuated total reflectance

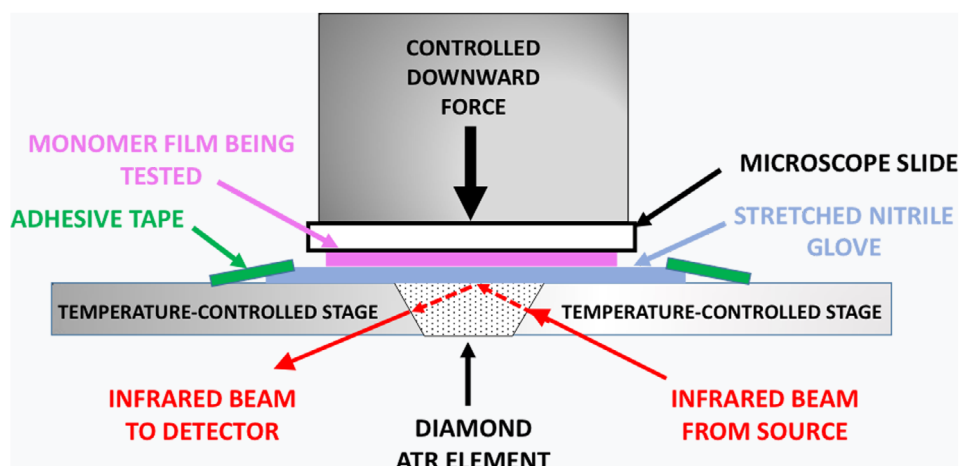


TABLE 2 Mean nitrile glove permeation times (min) of neat monomers and a commercial adhesive resin

Compound	Description	Glove penetration time (min)	SD	Statistical grouping
Bis-GMA	Neat monomer	>180	-	A
GDMA		43.3	6.9	B
TEGDMA		11.7	1.6	CD
HEMA		6.3	2.1	D
Optibond FL Adhesive	Commercial product	18.1	4.6	C

Note: $N = 5$ specimens per condition.

Abbreviations: Bis-GMA, 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane; GDMA, glycerol 1, 3-dimethacrylate; HEMA, 2-hydroxyethyl methacrylate; TEGDMA, triethyleneglycol dimethacrylate.

using a 1-way ANOVA and Tukey's post-hoc test at a pre-set alpha of .05.

5.5 | Results

Mean glove permeation times and monomer molecular weights are presented in Table 2.

Within the statistical grouping column, penetration times identified with similar letters are not significantly different.

During 3 hours of scanning, Bis-GMA never permeated the glove and was thus deleted from the statistical analysis of monomers that demonstrated permeation. The monomer GDMA took the longest time, and HEMA the least. However, there was no significant difference in permeability times between HEMA and TEGDMA. In addition, there was no significant difference in permeation times between TEGDMA and the adhesive components of the commercial adhesive agent. However, note that TEGDMA is not a listed component of the commercial adhesive tested.

6 | DISCUSSION

The results confirm the supposition of the first research hypothesis; there were significant differences among permeation times of the

neat monomers present in the commercial product through the nitrile glove worn by the presenting students. The permeation time of the commercial bonding adhesive mixture was found to not be significantly different from that of the neat TEGDMA monomer, validating the second research hypothesis. However, the spectral absorption profile observed for the initial permeated component of the commercial product through the nitrile glove appeared more similar to the spectrum of HEMA than it did to TEGDMA. Recall that TEGDMA was not a listed component of the commercial adhesive product. These differences and similarities are distinguished by comparing the chemical structures of the two monomers of interest, as highlighted in the insert panels of the following spectral profile overlay plots. In these inserts (Figures 3 and 4), the "methacrylate" functional groups are denoted using tan squares, whereas the important differences in structure between the monomers are highlighted by the presence of hydroxyl ($-\text{OH}$) groups in HEMA (green circle), and ether linkages ($\text{C}-\text{O}-\text{C}$) in TEGDMA (blue circle). These functional groups will be used to help identify the composition of monomer in the commercial adhesive product first permeating through the nitrile glove, as described in the following.

Figure 3 depicts a portion of the infrared (FTIR) spectrum associated with hydroxyl group ($-\text{OH}$) absorbance. Differences among the profiles of the component of the commercial bonding adhesive first permeating through the nitrile glove (red profile) are contrasted with those of the neat monomers: HEMA (green profile) and TEGDMA

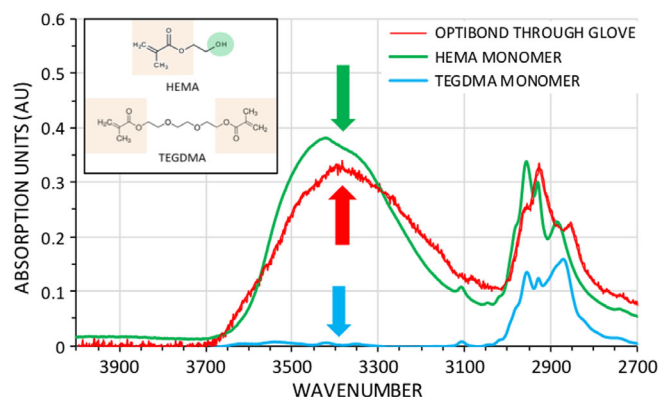


FIGURE 3 Spectral overlay of infrared absorption profiles of the permeated neat monomers HEMA (green profile) and TEGDMA (blue profile) as well as that of the commercial adhesive component first demonstrating glove permeation (red profile). HEMA, 2-hydroxyethyl methacrylate; TEGDMA, triethyleneglycol dimethacrylate

(blue profile). In this figure, attention is focused on the broad absorption peak occurring near 3400 cm^{-1} for the commercial adhesive material that first permeated through the glove. This spectrum was obtained by subtracting the spectrum of only the glove at the beginning of data acquisition from the absorbance values after the run had completed. In this manner, the influence of confounding absorption peaks associated with the glove components were eliminated. The specific spectral region noted within this range is that of the hydroxyl group (—OH) associated with HEMA (green arrow).⁴⁰ Note that there is a similar peak for the commercial bonding agent (red arrow), but a total absence of absorption for the neat TEGDMA monomer profile (blue arrow). (See Figure 3 insert).

Figure 4 presents IR absorption profiles of the same components, but within a different spectral region, containing absorption peaks characteristic of the specific functional groups for each neat monomer (as well as the commercial adhesive material). In this figure, note the high absorbance of TEGDMA in the spectral range between 1100 and 1150 cm^{-1} (blue arrows). These bands can be correlated with the multiple ether linkages (C—O—C) present in TEGDMA.⁴⁰ In the insert panel, note the presence of these groups in that monomer, and their absence in HEMA. Within this spectral range, neither HEMA nor the spectrum of the commercial adhesive resin obtained by permeation through the nitrile glove show any absorption peaks. In addition, it is seen that both HEMA and the adhesive bonding resin both showed an absorption peak near 1075 cm^{-1} , while there was none for the neat TEGDMA monomer. Absorption in this frequency range indicates the presence of a C—O stretch associated with an alcohol (the —OH group in HEMA), and its absence in TEGDMA (again, see structural differences presented in the inserted panel).⁴⁰

Thus, from this evidence, it is thought that the initial permeated component of the commercial adhesive product was, in fact, HEMA, although the time of glove permeation corresponded better with TEGDMA. This finding is supported by the similarities in spectral profiles as noted in the figure inserts. However, TEGDMA is not a listed component of the commercial adhesive product used.³⁹ The reason

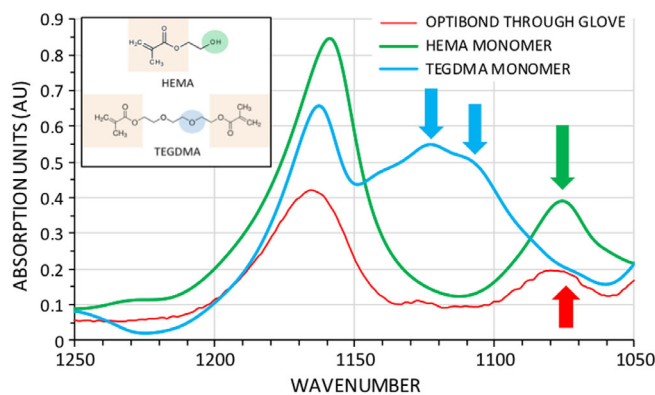


FIGURE 4 Differences in spectral absorption profiles among the commercial bonding adhesive that first permeated through the nitrile glove (red profile), and those of neat HEMA (green profile) and TEGDMA (blue profile) monomers. HEMA, 2-hydroxyethyl methacrylate; TEGDMA, triethyleneglycol dimethacrylate

for the delayed permeation time of HEMA in the commercial adhesive material could have been due to the colligative property of liquids, and its dilution among all other components in the commercial adhesive product. This property reflects a behavior of mixtures, where the nature of the mixture may not reflect those of the individual chemical components, but rather, is reflective of the ratio and possible interaction of their presence. The MSDS sheet of the product did not specifically state the relative composition of the monomers present, nor did published literature.³⁹ However, if there were more Bis-GMA or GDMA molecules present than HEMA, then permeation of HEMA could be delayed. In addition, all these monomers tend to have locations of small net charges along their backbones. The interaction of these charges among the monomers themselves would hinder diffusion of one individual species relative to another. Looking at the relative permeation times in Table 2, it can also be seen that there is a correlation between molecular weight and ability to transverse the nitrile glove: faster permeation times are associated with smaller molecular weight monomers. Stretching the glove, as when clinically worn, physically enlarges pore openings, allowing larger sized molecules to pass through. Thus, the findings can also be looked at as if the glove acted as a pore size-based membrane, perhaps with a larger proportion of smaller-size openings than larger ones. This concept would help to explain the relative speed with which each neat monomer diffused through. It should also be emphasized that the commercial adhesive product component does not list any solvent (ethanol or acetone) in the product that might affect monomer transport rate or spectral interpretation.

6.1 | HEMA (the potential biggest problem)

Based on the present research, HEMA is likely to be the initial monomer in the commercial bonding agent to permeate the nitrile gloves worn by the presenting students. Although not listed as a component of the commercial bonding agent, TEGDMA was found to permeate

at a statistically similar time as the initial monomers of this commercial product.⁴¹

Among the most popular monomers used in commercial adhesives, HEMA has hydrophilic properties, low molecular weight, and solvent ability, which ensure optimal wetting of dentin.⁴²⁻⁴⁴ The HEMA monomer acts as a surfactant, and is soluble in both aqueous and lipid environments.

Previous investigation clearly indicates that monomers having lower weights, such as Methyl methacrylate (MMA) and HEMA, easily permeate gloves. One possible explanation for this result is that monomers may infiltrate the molecular network gaps (pores) present in the polymer structure of the glove. This process may be regulated by the viscosity of the monomers, which is certainly influenced by their molecular weight and weak inter-molecular attractions. In that previous study, the authors used ethanol as a solvent, but acetone promotes even more rapid transport.⁴⁵ It should be noted that there is no solvent listed as present in the commercial adhesive agent tested in our study. The primer of that system contains ethanol, which is hopefully evaporated from the tooth by the time the adhesive is placed on top; the primer is never placed on a gloved hand to help with instrument lubrication: only the adhesive portion. In addition, the viscosity of the commercial adhesive tested is increased by addition of small inorganic fillers. Such an increase in viscosity would also hinder the rate of monomer diffusion, especially considering that filler particles may act to occlude inherent gaps (pores) in the glove polymer structure. MMA, HEMA, and TEGDMA penetrate nitrile and natural rubber latex gloves more easily than other types of gloves when dissolved in acetone, as compared with ethanol.⁴⁶

In addition to the risk of developing contact allergies, repeated exposure to unpolymerized methacrylates may be responsible for finger or hand neuropathies, with burning or prickling sensations being noted upon exposure.^{47,48} Several studies specifically mention the effects of HEMA, identifying it as a key component in the toxic response.⁴⁹ Cellular toxicity of HEMA has been identified by apoptosis or necrosis in human primary cells and by DNA damage; the possibility of systemic mutagenic effects has been raised.⁵⁰⁻⁵⁵

7 | GLOVE PERMEABILITY

Previous studies found nitrile gloves to be comparable to latex gloves in terms of barrier protection,⁵⁶⁻⁵⁹ durability, and resistance to puncture.^{60,61} However, nitrile gloves have less elasticity,^{58,61} resulting in reduced dexterity for fine motor skills, as compared to latex gloves.⁶¹ However, there are still insufficient clinical data concerning the use of disposable nitrile gloves in clinical dentistry. According to other studies, this type of glove offers fair-to-bad protection against acrylates that can act as sensitizers, producing dermatitis as experienced by the students in the present work.⁶²⁻⁶⁴ Thus, the results of the current study clearly show that monomers of lower molecular weight, such as HEMA, can easily permeate gloves, and may act as possible sensitizing agents, in susceptible operators.

7.1 | Clinical implications

Precluding issues from latex allergies, knowledge that nitrile gloves are permeable to components of a commercial dental adhesive product within a short time period might alter clinical behavior when using these gloves. Thus, one would strongly advise against any clinical procedure that includes such contact, while keeping in mind that a delayed contact is possible from permeation through nitrile gloves. Chair-side delivery methods should be adapted to avoid any exposure, not only to clinicians but also to dental auxiliaries who handle the same products.

On average, a monomer component of the commercial dental adhesive tested in this research was found to permeate nitrile gloves within 18 minutes. However, with respect to clinical treatment times, it is advisable to routinely change out gloves every half an hour or so. Resin permeability could be enhanced by glove stretching over a hand, as well as by the presence of fluids (sweat on one side, and water on the other) that might act as transport mediums, speeding monomer movement across the glove layer. Wearing inappropriately small-sized gloves over large hands, where the glove becomes excessively stretched, may also result in an increase in pore size, and thus also increase the potential for monomer transport as well as that of bacterial and viral components.

Finally, it must be stressed that, in individuals who have become sensitized to methacrylates, any continued direct contact will exacerbate an already existing allergic reaction cascade. The exposed operator is then susceptible to similar types of reactions to any methacrylate monomer, perhaps leading to the necessity of life-altering behavior patterns. In sensitized individuals, even inhalation of methacrylate monomers can elicit an allergic reaction. It is difficult to conceive of a contemporary dental practice that does not routinely use methacrylate-based restorative materials. Thus, clinicians should use every precaution to not become sensitized, and if sensitized, to avoid continued contact that may lead to increasingly severe reactions.

Not everyone presents with the same potential for methacrylate sensitivity. However, it is a fact that a portion of the population, if placed in an environment where long-term exposure is present, will become sensitized to this class of compounds. Thus, close attention to limiting contact with any type of unpolymerized methacrylate-containing material should be considered for all modes of interaction (directly on the skin, through inhalation, or indirectly through barrier gloves). It is up to the facility providers, as well as the individual practitioners themselves, to be aware of the risks inherent with use of methacrylates and of the need to provide instruction on appropriate methods that clinicians and ancillary personnel should take to limit such exposure.

8 | CONCLUSIONS

Based on the limitations imposed by this small sample, clinical case sampling, and subsequent glove permeation study, the following conclusions may be made:

1. The diffusion times of resin through stretched nitrile glove specimens significantly differ among methacrylate-based monomers.

2. The nitrile glove permeation time of Bis-GMA, a known adhesive component, exceeded the 180-minute time limit.
3. HEMA, a known potent allergen and component of the filled adhesive that is suspected in causing the observed skin reactions, has the fastest permeability time of all monomers tested.
4. TEGDMA, although having a glove permeation time not significantly different from that of the commercial bonding adhesive, is not a stated component of that product.
5. Strong evidence exists that the monomer in the commercial bonding agent first permeating through the nitrile glove may have been HEMA. Diffusion of this monomer from the commercial product co-monomer mixture could have been slowed as a result of the presence of filler (increased viscosity) as well as from the influence of the colligative influence of other co-monomers in the commercial adhesive.

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CONFLICT OF INTEREST

The authors do not have any financial interest in the companies whose materials are included in this article.

AUTHOR CONTRIBUTIONS

A. Sananez gathered data, developed literature review, and helped write paper. A. Sanchez performed dermatology examinations of dental students and provided report, and critically reviewed/revised paper. L. D. oversaw work of the Dermatology Resident and critically reviewed/revised paper. Y. V. gathered experimental data, coordinated database of students presenting with issues, and critically reviewed/revised paper. F. R. conceived of project, developed experimental method, performed interpretation of infrared spectra, performed statistics, and helped write paper.

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