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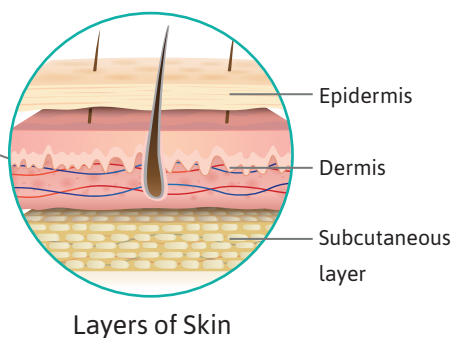
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The background of the entire page is a photograph of a dentist in a clinical setting. The dentist is wearing a white lab coat and blue nitrile gloves. They are holding a white dental syringe with an orange plunger and are dispensing a clear liquid into a white, U-shaped dental mold. The mold is being held by the dentist's gloved hand. The background is slightly blurred, showing the dentist's torso and arms.

PROTECTING HANDS FROM CHEMICALS IN DENTISTRY

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INTRODUCTION



Skin acts as the first line of defense. Nearly impenetrable, waterproof and resistant to most toxins and enzymes of invading microorganisms.

The skin is the largest organ in the body and acts as a protective barrier against the external environment. When irritated or inflamed, its barrier integrity becomes compromised, allowing bacteria, viruses and toxins to penetrate more easily.¹ Skin irritation and hand dermatitis are particular problems for dental professionals. In addition to frequent hand washing and the use of sanitizers which cause skin dryness, dental professionals work with many chemicals that have the potential to damage skin.

The use of medical gloves is an important part of a broader infection control and prevention program in dental practices. Using gloves helps to ensure skin is protected against both microorganisms and chemical splashes. Dental professionals must still educate themselves, however, about the chemicals they work with. Many chemicals have the ability to permeate through medical gloves to irritate skin or cause even more serious health problems. In addition, some studies suggest that when chemicals compromise the barrier integrity of gloves, there can be increased microbial penetration.² Increased microbial penetration can lead to higher risk of infection and cross contamination.^{3,4}

Given the important role they play in protecting the health of patients and clinical staff, careful consideration should be given to how well gloves protect against not only microorganisms^{5,6}, but also the various chemicals dental professionals work with each day.

OCCUPATIONAL DERMATITIS IN HEALTHCARE WORKERS

The incidence and prevalence of Allergic Contact Dermatitis in the general population are not known. Data is often extrapolated from surveillance studies on occupational dermatitis. In industrialized nations, up to 30% of all occupational diseases involve the skin. Irritant and contact dermatitis account for more than 90% of cases.⁷

Surveillance studies have reported an annual incidence of contact dermatitis (including irritant and allergic contact dermatitis) of 13 to 34 cases per 100,000 workers.⁸⁻¹⁰ The agents most frequently implicated included latex materials, protective equipment, soap and cleansers, resins, and acrylics.

Large scale clinical studies concerning glove use in dental care settings are not as extensive as studies conducted in general medical or hospital care settings. Extrapolations from studies in other disciplines have been made to help form a basis for recommendations about gloves for dental professionals.¹¹

Allergic contact dermatitis caused by exposure to acrylic compounds has become common among dentists and orthopaedic surgeons. The increased use of acrylic compounds as substitutes for amalgam by dentists, dental nurses, and dental technicians has caused a surge in the incidence of hand eczema among these groups. These compounds can permeate the barrier of medical and surgical gloves after a short period of time, leaving the professionals working with these gloves unprotected.

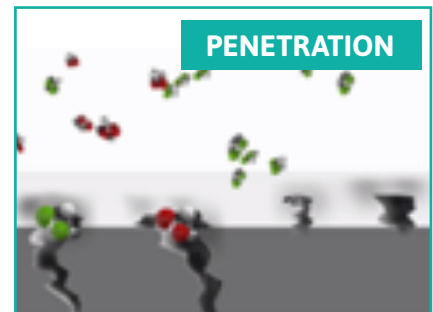
Some research points to the possibility that the use of chemicals can compromise glove barriers, making it easier for microorganisms to permeate. In one study, latex gloves were treated with acrylic monomer, chloroform, and orange solvent and then exposed to herpes virus. Significant amounts of the virus leaked through the glove in a “virus leakage” test. When the gloves were treated with bleach, soap, and 30% phosphoric acid etchant, however, little of the virus was detected, and no virus leakage was found when gloves were treated with composite resin, ethanol, formocresol, and water.² This indicates that exposure to some chemicals may compromise the ability of a glove to protect against microorganisms. In yet another study of the effectiveness of medical gloves in protecting against methyl methacrylate (MMA), ethylene glycol dimethacrylate (EGDMA), and 1,4-butanediol dimethacrylate (1,4-BDMA), exposure to these monomers on the outside surface of the glove resulted in substantial swelling of the glove materials and structure changes to the inside surface of the glove.¹² These changes in glove surfaces should be evaluated more to ensure prolonged exposure of the gloves to chemicals does not affect the barrier function.



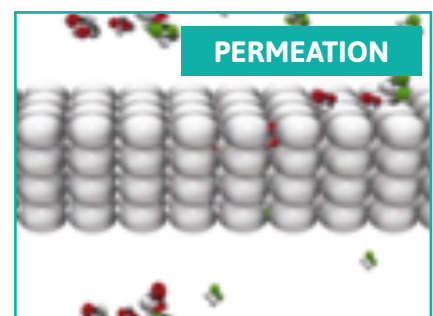
Most dental professionals’ gloves are not exposed to chemicals continuously or for long durations. Their gloves are instead exposed to chemicals only in the event of a splash, for brief periods of time. However, depending on the chemical, its concentration, and volatility even limited exposure may cause molecular changes to the glove material, allowing for permeation. In most instances of chemical permeation there is no visible wetness, change in sensation or impact to skin integrity at the time of exposure. Repeated exposure to chemicals over time, however, will eventually lead to irritant contact dermatitis or allergic contact dermatitis. These skin conditions are much harder to diagnose due to delayed reaction.

PENETRATION AND PERMEATION

The penetration of chemicals and/or microorganisms is a process which can be defined as the flow through closures, porous materials, seams, and pinholes or other imperfections in a protective or medical glove material. Penetration occurs on a nonmolecular level, and can lead to contact with hazardous chemicals or infectious materials, especially in the healthcare field.¹³⁻¹⁵



Permeation is a process by which a chemical can pass through a protective film without going through pinholes, pores, or other visible openings. Individual molecules of the chemical enter the film, and “squirm” through by passing between the molecules of the glove compound or film. In many cases the permeated material may appear unchanged to the human eye. Permeation is measured in the number of minutes it takes for a chemical molecules to pass through the glove material.^{2,16,17}



GLOVES AND CHEMICAL PROTECTION

A glove that protects against one type of chemical may offer poor protection against another chemical. Different types of gloves protect against different types of chemicals. This means that dental professionals should carefully choose their gloves in part based on the chemicals they may be exposed to during their work.

Polymer	Good Resistance To...	Poor Resistance To...
Natural Rubber	• Aqueous solutions • Acids • Bases • Alcohols	• Organic chemicals • Oils • Ketones
Nitrile	• Many solvents (organic) including Aliphatic Hydrocarbons, oils, fats	• Strong acids • Halogenated hydrocarbons • Aldehydes • Ketones
Neoprene	• Aldehydes • Acids • Bases • Alcohols • Different solvents	• Aromatic solvents • Halogenated solvents • Ketones

A medical glove's ability to resist chemicals is limited in time. The length of time it can resist the chemical depends upon several factors. These include the type of material the glove is made from; the quality of the formulation and manufacturing process used when making the glove; the thickness of the glove material; the composition and concentration of chemical in the product or chemical mixture chemicals; the frequency and duration of contact with the chemical mixture (short or long period of time); and the nature of chemical contact (total immersion, or exposure to a "splash"). After a while, the chemical will penetrate the medical glove material, often without being noticed.

A glove's chemical resistance is dependent on certain key factors:

- 1 Type of polymer / material glove is made from
- 2 Quality of glove formulation and manufacturing process
- 3 Thickness of glove material
- 4 Composition and concentration of chemicals glove is exposed to
- 5 Frequency and duration of contact with chemical(s) (short or long)
- 6 Nature of contact (total immersion or splash)



Another factor impacting how long a glove will resist chemicals not mentioned is temperature. At higher temperatures, it will take less time for a chemical to penetrate a glove than it will at lower temperatures.

Many people would assume that two gloves with a similar thickness made with the same polymer would have the same ability to resist a chemical. This, however, is not always the case. The formulation and manufacturing process used in making a glove can have an impact on how long it can resist chemicals. The ability of a glove to protect for a given length of time against a given chemical / mixture can therefore only be determined by testing specific gloves against specific chemicals / mixtures. Another factor complicating our ability to determine how long gloves can resist chemicals is glove movement. The simple, everyday movements that a person makes while wearing a glove and performing job tasks can affect how quickly chemical permeation occurs. In chemical permeation tests that simulate these types of everyday movements, chemical breakthrough times are significantly shortened.^{12,17,18,19} Abrasion, even in controlled, non-severe conditions, may compromise to varying degrees the barrier integrity of latex, vinyl, SEBS, nitrile, and neoprene glove materials.

CHEMICALS IN DENTISTRY AND COMMON SIDE EFFECTS EXPERIENCED BY GLOVE USERS

Occupational contact dermatitis etiologic factors for dental professionals include reactions to latex proteins, as well as reaction to various dental materials, detergents, lubricants, solvents and chemicals present in dental products. In recent years, there have been increased problems with severe adverse reactions in health care workers caused by exposure to latex products such as gloves.²⁰⁻²⁷ Examples of different chemicals present in dental products that cause skin irritation are included in the figure below.

Dental Product	Relevant Chemicals
Cleaning agents / Disinfectants / Enzymatic cleaners	Methyl Ethyl Ketones, Quaternary Ammonium Compounds, Alcohols, Sodium Hypochlorite, Hydrogen Peroxide, Sodium Bicarbonate, Sodium Hydroxide
Fluoride varnish	Ethanol, Resin, Sodium Fluoride
Temporary cements	Eugenol, Zinc Oxide
Composite resins	Methacrylates
Impression materials	Polysulphides
Root canal irrigation liquids	Sodium Hypochlorite, Tetrasodium ethylene diamine tetraacetate
Acid etch	Phosphoric acid
Dental Hemostatic Agent	Iron sulfate, Propylene Glycol, Zinc Chloride, Aluminum Sulfate
Bonding agents	Methacrylates
Dental Adhesives	Siloxanes, Acetones, Methacrylates
Anesthetics agents	Preservatives (e.g., methyl-p-hydroxybenzoate), Antioxidants (e.g., bisulphate), Antiseptics (e.g., chlorhexidine)

Skin irritation may also be caused by other factors:

- Exposure to other irritants such as rubber chemicals, organic pigments, glove powder, or chromate in leather gloves.
- Irritant reactions to gloves, e.g., mechanical stress, occlusion, sweating, maceration, endotoxins, ethylene dioxide.
- Exposure to non-volatile chemicals that remain on work surfaces for long periods of time.

Adverse reactions due to rubber chemicals, powder, lubricants, endotoxins, and pyrogens are well known and more frequent than reactions to proteins. There is a risk that various forms of skin problems may occur, such as hand eczema. This condition can affect up to 10% of the population.

Dental personnel report experiencing contact dermatitis and asthma following exposure to Methacrylates. Methacrylates have been known to be responsible for occupational contact allergies.²⁸ Other studies have recognized Methyl Methacrylate monomer as the main cause of allergic dermatitis in dentists and dental laboratory technicians.²⁹ Eugenol is another chemical commonly used in the dental environment and cytotoxic in high doses. In lower doses, it is also reported to cause hypersensitive Type IV-delayed adverse reactions and rarely a generalized allergic response.³⁰

No standard medical exam grade nitrile, neoprene or latex gloves can resist Ketones or Methacrylates for a substantial length of time. Avoiding exposure to these chemicals is therefore the best solution to avoid long term skin issues. Latex and nitrile gloves provide only limited protection against allergenic Methacrylates in dentin bonding agents.^{31,32} Double gloving may be considered to increase the permeation time, but dental professionals should be aware that double gloving will not stop the permeation process.

CONCLUSION

The prevalence of occupational contact dermatitis among dental personnel has steadily increased over the last two decades and studies suggest it is now between 15% and 33%.³³ This is a concern because damaged skin is less effective at protecting against disease, ultraviolet rays, and other external irritants. In addition, hand eczema allows for easier permeation of chemicals through the skin and into the body

Strong emphasis on compliance with basic hygiene recommendations as well as infection control regulations is necessary to counter the increased risks of healthcare associated infections. Compliance with these guidelines is particularly important given the increased antimicrobial resistance of many bacteria. Strict hand hygiene and the proper use of medical and protective gloves are two of the most effective ways to prevent infection.

In addition to preventing exposure to bloodborne pathogens and bacteria, however, it is also important for healthcare workers to focus on preventing exposure to chemicals. As new and stronger disinfectants and cleaning agents become available, and technological advancements drive the use of more chemical substances such as resins for 3D printers, dental professionals are increasing at risk of contact dermatitis or more serious systemic health problems caused by chemical exposure. Clinicians should be aware of the adverse reactions associated with the chemicals they work with as well as factors that can potentially heighten the permeation of these chemicals through skin. Excessive hand washing, use of hand sanitizers, wet work, and exposure to chemical mixtures can all damage skin condition potentially enhancing the ability of chemicals to permeate. This may lead to other adverse biological responses.

Historically, there has been little focus on skin exposure to chemicals in occupational settings. Without adequate information on occupational exposure limits for chemicals in a dental setting, it is essential that dental professionals correctly evaluate their personal protective equipment and medical grade gloves to help minimize the risk of exposures.

Increasing awareness about the health risks of chemical exposures among dental professionals and evaluating chemical permeation of more dental products against medical grade gloves can help address and minimize occupational contact dermatitis in dentistry.

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