

# An in-vitro study of the effects of various disinfectants on prosthetic and surface materials

Salma A. Bahannan, BDS, MSc, Maha M. Abdel-Salam, BDS, PhD.

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## ABSTRACT

**Objectives:** This study assessed the effect of various disinfectants on several contaminated prosthetic and surface-covering materials.

**Methods:** The efficacy of 6 disinfectants used at King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia, on prosthetic and surface-covering materials, irreversible hydrocolloid and elastomer impression materials, wax, acrylic resin, metal, bench-covering material, and floor carpet. These materials were contaminated with *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus*. Counts of viable bacteria on the materials was determined by incubated replica plating on blood agar plates at 5 minute intervals. A 3 way non parametric analysis of variance was used to evaluate the main effects and interactions of the disinfectants, bacteria, and materials.

**Results:** Statistical analysis showed that material, type of disinfectant, and interactions between material and bacteria were significant. Carpet has a significantly higher bacterial count than many other items ( $P < 0.0001$ ) such as acrylic resin, irreversible hydrocolloid, chrome-cobalt casting, and laminated bench surfaces.

**Conclusions:** Quaternary ammonia compound and the tertiary ammonia phenol were the most effective disinfectants. Efficacy of the disinfectant depends partly on the bacteria used for contamination. Carpets in dental clinics showed high potential to retain microorganisms.

**Keywords:** Disinfectant, prosthetic, wax, impression materials, casting alloy.

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The routine exposure of dental practitioners and auxiliaries, to a multitude of bacterial, viral, and other microbial pathogens led to the development of cross infection control protocols and recommendations initially directed at preventing hepatitis B virus (HBV) transmission.<sup>1</sup> The same recommendations and protocols were more recently applied to human immunodeficiency virus (HIV) infection. Of interest also, to the problem of cross-infection control, Is the dental laboratory, and the potential role of infection transmission from patient to dental technician and vice versa has been documented.<sup>2</sup> However, many items used in

prosthodontics, such as, certain impression materials cannot be routinely sterilized without damage and distortion. This is an important consideration for the office personnel as well as dental laboratory technicians.

The British Dental Association (BDA),<sup>3</sup> the American Dental Association (ADA),<sup>4-7</sup> the Centers for Disease Control (CDC),<sup>8,9</sup> and others<sup>10-17</sup> have issued guidelines for cross infection control in the dental office and laboratory. The ADA has accepted 4 categories of disinfectants for use in dentistry, which are chlorine compounds, iodophors, synthetic phenolics, and neutralaldehydes. At King Abdulaziz

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From the Department of Oral and Maxillofacial Rehabilitation, (Bahannan), and the Department of Oral, Basic and Clinical Sciences, (Abdel-Salam), Faculty of Dentistry, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia.

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Address correspondence and reprint request to: Dr. Salma A. Bahannan, Faculty of Dentistry, PO Box 1540, Jeddah 21441, Kingdom of Saudi Arabia. Tel. +966 (2) 6403443. Fax. +966 (2) 6403316. E-mail: sbahannan@kaau.edu.sa

University, Jeddah, Kingdom of Saudi Arabia (KSA), products of those disinfectants are used in addition to a quaternary ammonium compound. The purpose of this study was to assess the effect of those disinfectants used on several prosthetic and surface covering materials.

**Methods. Disinfectants.** Six types of dental disinfectants, as shown in **Table 1**, were tested. Solutions requiring dilution were prepared according to manufacturer's instructions immediately before use.

**Materials.** Prosthetic items and surface coverings were; 1. Irreversible hydrocolloid impression material (Jeltrate, Dentsply International Inc., Milford, Delaware (DE), United States of America, (USA)) mixed with sterilized water and prepared according to the manufacturer's recommendations, and cut into one inch squares 2. Elastomeric impression material (President, Cottene Whaledent Inc., Mahwah, New Jersey, United States of America, USA), mixed according to the manufacturer's instructions, placed in sterilized plastic molds, and cut into one inch squares 3. Bite registration wax (Kerr, Bretton, Peterborough, United Kingdom), cut into one inch squares 4. Heat cured acrylic resin specimens (Lucitone 199, Dentsply International Inc., Milford, DE, USA), used as one inch squares 5. Chrome-cobalt casting ingots alloy (Ugin dentaire, Seyssins, France). Materials 3, 4, and 5 were treated with a bactericidal wipe, saturated with 70% solution of isopropyl alcohol just prior to the experiment 6. Bench: Sheets of laminated plastic countertop material (Formica) were cut into one inch squares and disinfected by soaking in 2% gluteraldehyde for 10 minutes; and 7. Carpet specimens (Interface Flooring System, Inc., La Grange, Georgia, USA) were cut into one inch squares and autoclave sterilized.

**Contaminating and wiping procedures.** To ascertain the effects of various disinfectants, tubes containing freshly collected heparinized human blood were placed in a 56°C waterbath for 30 minutes to inactivate complement system components, and hence inhibit their effects on microbial agents. Twenty four hour bacterial cultures in normal saline were obtained from the Department of Microbiology at King Abdulaziz University, Jeddah, KSA. For this purpose, 3 types of bacteria were used, *Pseudomonas aeruginosa* (*P.aeruginosa*), *Escherichia coli* (*E.coli*), and *Staphylococcus aureus* (*S.aureus*). These 3 organisms are commonly isolated in hospitals. *Staphylococcus aureus* is a gram-negative bacteria, *E.coli* is gram-positive and *P.aeruginosa* is known by its resistance to disinfectants. Of each bacterial suspension, 0.5ml was mixed with 5ml of collected blood to give a final dilution of 1:10, which was used to wet all tested materials. After applying the bacterial mixture to each tested material with a

cotton swab, the materials were allowed to air dry for 15-20 minutes, and then they were treated with a single spray (0.8ml) of each disinfectant and excess disinfectants removed using sterile gauze.

**Replica plating procedure.** Viable bacteria which, was present on the materials 5 minutes later was determined by replica plating on blood agar plates. Plates were incubated aerobically at 37°C for 36 hours before observing the microbial growth. A control uncontaminated sample for each material was incubated as a negative control. Blood bacteria mixture was swabbed onto each plate as control for bacterial growth.

**Estimation of viable microorganisms after disinfection.** Growth of bacteria was estimated for each case on a scale of 0-4. Lack of bacterial growth or presence of less than 5 colonies was given a 0; presence of 6-30 colonies were given a score of 1; 30-50 colonies, scored 2; and more than 50 scored 3. In some cases confluent growth of colonies were seen and these were given a score of 4.

**Statistical analysis.** Using bacterial count as the dependent variable of the study, a 3 way non-parametric analysis of variance (ANOVA) was used to evaluate differences in bacteria, material, and disinfectants and their interactions. Tukey type non-parametric post hoc test was used to detect the differences between groups.

**Results.** There was no bacterial growth in plates containing uncontaminated material samples. Viability of bacteria in each test was also demonstrated. **Table 2** presents means and standard deviations of materials, disinfectants, and bacteria.

**Table 1** - Studied disinfectants.

Brand	Active ingredient	Manufacturer
Birexse	Phenylphenol, tertiary amyphenol 14.1%	Bristol International Louisville, CO, USA
Durr system Hygiene	Quaternary ammonium compound	Bietigheim-Bissingen, Germany
Coe-spray	Ophenyl phenol ethyl alcohol	GC America Inc., Chicago, IL, USA
Coe-Cide	2% alkaline glutaraldehyde	GC America Inc., Chicago IL., USA
Asept-All Idophor	Iodine (75 ppm)	Englewood, NJ, USA
Chlorox	Sodium hypochlorite (5000ppm)	
CO - colorado USA - United States of America IL - Illinois NJ - New Jersey ppm - part per million		

**Table 2** - Means and standard deviations of bacterial growth.

Item	Mean	Standard Deviation
<b>Materials</b>		
Carpet	2.83	0.92
Bite registration wax	2.39	0.85
Heat cured acrylic resin	1.94	0.64
Irreversible hydrocollid	1.83	0.51
Elastomeric impression material	2.39	0.70
Bench laminated sheets	1.56	0.86
Chrome-cobalt casting ingots	1.78	0.88
<b>Disinfectants</b>		
Birex	1.76	0.89
Durr system hygeine	1.76	0.62
Coe spray	2.05	0.67
Coe-Cide	2.48	0.93
Asept-All Iodophor	2.19	0.98
Sodium hypochorite	2.38	0.86
<b>Bacteria</b>		
<i>P.aerugionosa</i>	2.00	0.88
<i>E.coli</i>	2.10	1.01
<i>S.aureus</i>	2.21	0.68
<i>P.aerugionosa - pseudomonas</i> <i>E.coli - escherichia</i> <i>S.aureus - staphylococcus</i>		

Non-parametric ANOVA shows that there is no significant effect of bacterial type on bacterial count ( $p > 0.05$ ;  $df=2$ ). Materials and disinfectants used have a significant effect on bacterial growth. The p-values for material and disinfectant were ( $p < 0.0001$ ;  $df=6$  and  $p < 0.05$ ;  $df=5$ ). Tukey type non parametric post-hoc test indicates that carpet has significantly the highest bacterial count as compared to acrylic resin, irreversible hydrocolloid, chrome-cobalt casting, and laminated bench covering ( $p < 0.0001$ ).

Furthermore, laminated bench covering showed significantly lower bacterial count than bite registration wax and elastomeric impression material ( $p < 0.05$ ). Birex (quaternary ammonia) had the highest disinfecting effect on the bite registration wax, acrylic resin, irreversible hydrocolloid, elastomeric impression material and laminated bench ( $p < 0.05$ ). In addition, Durr (tertiary ammonia phenol) was effective on chrome-cobalt casting, bite registration wax, laminated bench covering and carpet ( $p < 0.05$ ).

**Discussion.** Increased awareness regarding the risk of transmission of infection by blood and saliva is reflected in the current level of concern regarding the disinfection of impression material and prosthetic items used in the dental clinic. A number of commercial disinfectant compounds from several categories of generic chemicals are widely used.

Although ADA, CDC, BDA and other organizations concerned have set uncompromisable rules regarding the infection control in dental clinics for such practices, there are great variations among different places in the world. In addition, the same manufacturer under different commercial names could produce disinfectants with the same active ingredients. Further, the effectiveness of these disinfectants depends on many factors including concentration and type of microorganisms, concentration of chemicals, length of exposure time and amount of accumulated organic debris.<sup>18</sup> In this study, the efficacy of some disinfectants was tested against 3 different species that are commonly isolated in hospitals and do not require specific media or atmosphere to grow and are easily isolated and identified in the laboratory. Mixing bacterial suspensions with heparinized human blood was assumed to produce an atmosphere similar to that encountered in contaminated dental items. Subsequently, the efficacy of disinfectant in presence of such organic materials would be close to reality. It was also expected that materials would react differently to accumulation of bacteria. In this study, carpet samples showed a higher potential to harbor microorganisms and appeared to be more difficult to disinfect at an acceptable level. Bacterial contamination, specifically with *S.aureus*, of rough carpet surface was greater than the smooth surfaces of chrome-cobalt casting ingots, or the laminated bench covering material, or irreversible hydrocolloid impression material. Disinfectants that contain tertiary phenol compounds were found most effective when applied to irreversible and elastomeric impression materials, acrylic resins and bite registration wax. While quaternary ammonia was found most effective in carpet and chrome-cobalt-casting ingots disinfection. The authors recommend conducting further studies to audit the efficacy of disinfectant regimens under various clinical conditions.

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