Effect of Hand Cleansing with Antimicrobial Soap or Alcohol-Based Gel on Microbial Colonization of Artificial Fingernails Worn by Health Care Workers

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This study was undertaken to determine differences in microflora on the nails of health care workers (HCWs) wearing artificial nails compared with control HCWs with native nails and to assess the effect on these microflora of hand cleansing with antimicrobial soap or alcohol-based gel. Cultures were obtained from 21 HCWs wearing artificial nails and 20 control HCWs before and after using antimicrobial soap or alcohol-based gel. Before cleansing with soap, 86% of HCWs with artificial nails had a pathogen (gram-negative bacilli, Staphylococcus aureus, or yeasts) isolated, compared with 35% of controls (P = .003); a similar difference was noted before hand cleansing with gel (68% vs. 28%; P = .03). Significantly more HCWs with artificial nails than controls had pathogens remaining after hand cleansing with soap or gel. Of HCWs with artificial nails, only 11% cleared pathogens with soap compared with 38% with gel. Of control HCWs, only 14% cleared with soap compared with 80% with gel. Artificial acrylic fingernails could contribute to the transmission of pathogens, and their use by HCWs should be discouraged.

Hand cleansing remains the most effective and least expensive measure to prevent transmission of nosocomial infections [1–3]. However, after even thorough hand cleansing, the fingernails, especially the subungual region, harbor a greater number of microorganisms than other areas of the hands [4–6]. This area is often neglected during routine hand cleansing [7].

The use of artificial acrylic fingernails has become popular in the past several years. It is estimated that over $265 million is spent every year on acrylic nails and related products and their application in the United States. Artificial nails are frequently worn by health care workers (HCWs), even though they are officially banned by the Association of Operating Room Nurses [8]. A previous study from our laboratory found significantly increased numbers of potentially pathogenic organisms (Staphylococcus aureus, gram-negative bacilli, and yeasts) associated with artificial nails when compared with native nails [6]. The current study was undertaken to compare the efficacy of antimicrobial soap and alcohol-based gel hand cleansing on colonization of natural and artificial fingernails. Alcohol formulations are widely used in Europe and have the advantages of saving time and perhaps providing better germicidal activity when compared with

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hand cleansing with soap and water [2, 3, 9–11].

PATIENTS AND METHODS

Study design. Volunteers were identified among HCWs in inpatient and outpatient care areas at the University of Michigan and the Veterans Affairs Medical Centers. A total of 21 volunteers (15 nurses, 2 respiratory therapists, 2 technicians, 1 pharmacist, and 1 ward clerk) wearing salon-applied, permanent polished acrylic artificial nails were compared with 20 control subjects (13 nurses, 6 physicians, and 1 respiratory therapist) who did not wear artificial nails. Volunteers with dermatitis or other abnormalities of the skin of their hands were excluded, as were those who wore self-applied plastic nails or nails adorned with rhinestones or other studs. No special preparation of the hands was done before sampling. Culture samples were taken from volunteers at unscheduled times during their regular work activities; volunteers had cleansed their hands as usual on the day of the study, although hand cleansing was not permitted immediately before sampling. Before sampling on the first day of the experiment, the length, beyond the fingertip, of each nail of the dominant hand was measured and mean nail length was calculated.

After baseline sampling, volunteers were asked to cleanse their hands as they normally would with Medi-Scrub, our hospital’s approved antimicrobial soap, containing para-chloro-meta-xylene (PCMX; Huntington Laboratories) or with an alcohol-based gel (Isagel, Coloplast) that contained 60% ethyl alcohol. Cultures were then repeated. The volume of alcohol-based gel used was not recorded, although volunteers were asked to use a “nickel-sized” amount and to massage it into the hands until dry. The study was performed in 2 phases. Most volunteers used soap in the first experiment and then gel in the second phase of the study. A minimum of 7 days was required between the experiments for each volunteer.

Microbiological methods. Nail surfaces and subungual nail regions of the 5 fingers of the dominant hand were sampled by culture methods described elsewhere [6]. Quantitative cultures were performed with colistin-nalidixic acid agar containing 5% sheep’s blood (Becton Dickinson Microbiology Systems), MacConkey agar (Difco Laboratories), and Sabouraud dextrose agar (Difco) with 10 μg/mL gentamicin and 10 μg/mL vancomycin. Phenotypically different colonies were quantified and further identified. S. aureus, gram-negative bacilli, enterococci, and yeasts were considered to be potential pathogens. All organisms were identified by standard methods as previously described [6].

Statistical analysis. Frequency of isolation and quantity of organisms (mean log₁₀ colony-forming unit [cfu] ± standard error of the mean) were compared between HCWs wearing artificial nails and control subjects with native nails, between the surface and the subungual area of both types of nails, and before and after hand cleansing with either antimicrobial soap or alcohol-based gel. Frequency of isolation was compared with the χ² test; differences in the quantity of various organisms isolated and mean nail length of artificial nails and native nails were compared by Student’s t test. The quantity of organisms isolated from the surface and the subungual region of both types of nails and the quantity of organisms isolated before and after hand cleansing were compared by the paired t test. Significance was defined as P ≤ .05.

Figure 1. Percentage of health care workers (HCWs) wearing artificial acrylic fingernails and control HCWs with native fingernails from whom potential pathogens were isolated before hand cleansing with (A) antimicrobial soap or (B) alcohol-based gel. Statistically significant differences between HCWs with native nails and those with artificial nails for all pathogens and specific organisms are shown. GNB, gram-negative bacilli; SA, Staphylococcus aureus; ENT, Enterococcus. +, positive results in tests for listed organisms.

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RESULTS

HCWs wearing artificial acrylic nails had longer nails than control HCWs (mean length, 6.05 ± 0.37 mm vs. 2.52 ± 0.15 mm; P < .001). All HCWs wearing artificial nails wore nail polish; no control subjects wore nail polish. At baseline, HCWs wearing artificial nails were more likely than control subjects to have a pathogen isolated (figure 1). Before hand cleansing with soap, 86% of HCWs wearing artificial nails had a pathogen isolated, compared with only 35% of control HCWs (P = .003). A similar difference was noted before hand cleansing with gel (68% vs. 28%; P = .03). Before hand cleansing with either soap or gel, significantly more cultures from HCWs wearing artificial nails had pathogens isolated than control HCWs had S. aureus, gram-negative bacilli, and yeasts isolated.

The types of gram-positive organisms isolated from HCWs wearing artificial nails and control HCWs were similar (table 1). Coagulase-negative staphylococci were isolated from all baseline cultures, and both groups frequently had α-hemolytic streptococci, micrococcii, and diphtheroids isolated. Volunteers wearing artificial fingernails had more methicillin-susceptible S. aureus than control subjects and accounted for all isolates of methicillin-resistant S. aureus and enterococci. Enterobacter species, Pseudomonas species, Klebsiella oxytoca, and a variety of nonfermentative organisms were isolated from HCWs wearing artificial nails, but not from control HCWs. Candida parapsilosis was the yeast isolated most often from both groups.

The quantity (log_{10} cfu) of organisms isolated was greater in the subungual region than on the surface for HCWs wearing artificial nails (5.5 ± 0.2 vs. 4.4 ± 0.2; P < .001) and for HCWs with native nails (4.6 ± 0.2 vs. 3.9 ± 0.2; P = .003). When compared with control subjects, HCWs wearing artificial nails had a larger quantity of all pathogens (3.3 ± 0.2 vs. 2.1 ± 0.3; P = .004) and S. aureus (3.9 ± 0.33 vs. 2.2 ± 0.4; P = .02) but similar quantities of yeasts and gram-negative bacilli.

After hand cleansing with either agent, more HCWs wearing artificial nails had pathogens remaining than control HCWs (figure 2). After hand cleansing with soap, 17 (81%) of 21 HCWs wearing artificial nails had pathogens remaining compared with only 7 (35%) of 20 control HCWs (P = .008). Significantly more HCWs wearing artificial nails had yeasts (62% vs. 20%; P = .02) and gram-negative bacilli (43% vs. 5%; P = .01) remaining than did control subjects. Alcohol-based gel decreased colonization more than had been noted with soap. However, significantly more HCWs with artificial nails still had gram-negative bacilli than control HCWs; no HCWs with native nails had gram-negative bacilli isolated after hand cleansing with alcohol gel. The use of alcohol gel in the control group reduced the rate of carriage of pathogens to < 10%, whereas > 50% of HCWs with artificial nails still had pathogens on their nails.

Alcohol-based gel appeared to be more efficacious at removing pathogens than antimicrobial soap; hand cleansing with soap did little to decrease nail colonization (figure 3). Of 18 HCWs who wore artificial nails and who harbored pathogens at baseline, only 2 (11%) cleared those pathogens after hand cleansing with soap, whereas 5 (38%) of 13 had clearance of pathogens after the use of gel. Of 7 control HCWs who had pathogens isolated at baseline, only 1 (14%) showed clearance of pathogens with soap, compared with 4 (80%) of 5 who showed clearance after use of gel (P = .09).

DISCUSSION

The hands of HCWs frequently become contaminated in the routine care of patients [2, 12]. Organisms acquired in this manner tend to be transient and can be removed by hand cleansing. However, despite the efficacy of hand cleansing in removal of transient bacteria, the hands of HCWs with artificial nails have been repeatedly implicated as vehicles for transmission of nosocom-
Several factors could contribute to the continued role of HCWs in the transmission of pathogens. The most obvious factor is failure of HCWs to cleanse their hands [12, 18–25], and another is improper use of gloves [18]. Two additional factors that could potentially impact on the continued role of HCWs hands in the transmission of pathogenic organisms include the type of hand cleansing agent used and the characteristics of the hands of HCWs. In fact, a recent outbreak in a neonatal intensive care unit was linked to carriage of *Pseudomonas aeruginosa* on the nails of 2 nurses, one with long artificial nails and the other with long natural nails [17]. This study addresses the impact of the choice of the hand cleansing agent used on the effectiveness of hand cleansing and specifically focuses on the role that artificial acrylic fingernails might play.

Several previous studies, including ours, have found that HCWs wearing artificial fingernails had more pathogens, including gram-negative bacilli, yeasts, and *S. aureus*, isolated from their nails than those with native nails [6, 26, 27]. This study confirms those findings, and the findings of studies elsewhere, showing that the number of all organisms and the quantity of potential pathogens is greatest in the subungual region of the nails [5, 6]. In this study, the number of volunteers from whom pathogenic organisms were isolated was higher before hand cleansing with soap than before cleansing with alcohol-based gel. This may be explained by the fact that most volunteers completed the first experiment with soap and then used gel in the second phase of the study. This could have led to increased awareness of the purpose of the study among volunteers and therefore more thorough hand cleansing before the gel phase of the experiment.

This study demonstrates the inability of routine hand cleansing with antimicrobial soap to eliminate pathogens from artificial or native fingernails. The failure of antimicrobial soap to eliminate pathogenic bacteria from either native or acrylic nails was surprising. In an attempt to simulate normal conditions, volunteers were instructed to cleanse their hands as they usually would and were not mandated to do this for a prescribed period of time or to use any specified technique. As noted in previous studies, most volunteers washed with soap and water for a very brief period of time, often less than the recommended minimum of 10 s [21, 28]. Failure to cleanse hands thoroughly with an adequate volume of soap and for an adequate period of time has been shown to decrease the effectiveness of hand cleansing [29, 30]. Thus we cannot exclude the possibility that the failure of antimicrobial soap to eliminate microorganisms was due to inadequate hand cleansing technique by our volunteers and not to ineffectiveness of the antimicrobial soap.

The alcohol-based gel cleared pathogens from both artificial and natural nails better than antimicrobial soap. The superior germicidal activity of alcohol may have contributed to the improved efficacy, although poor hand cleansing technique with antimicrobial soap may also have contributed to the apparent superior efficacy of the gel. Alcohol-based hand cleansers are used extensively in European hospitals and have been shown to have efficacy and acceptance rates similar to or better than those of antimicrobial soaps [9, 10, 31, 32]. The use of alcohol-based formulations may increase hand cleansing compliance among HCWs for whom hand cleansing with soap and water represents an often prohibitive time commitment [3, 33]. Because we wanted to approximate real-world conditions in this study, we chose to use Medi-Scrub (Huntington Laboratories), the approved antimicrobial soap used in our hospital, for com-

**Figure 2.** Percentage of health care workers (HCWs) wearing artificial acrylic fingernails and control HCWs with native fingernails from whom potential pathogens were isolated after hand cleansing with (A) antimicrobial soap or (B) alcohol-based gel. Statistically significant differences between HCWs with native nails and those with artificial nails for all pathogens and specific organisms are shown. GNB, gram-negative bacilli; SA, *Staphylococcus aureus*; ENT, *Enterococcus*., positive results in tests for listed organisms.
Artificial nails may interfere with hand cleansing because of a desire to protect the manicure. Because we did not attempt to establish frequency of hand cleansing during routine patient care before baseline sampling, it is possible that the increased frequency of carriage of pathogenic organisms by HCWs wearing artificial nails represents systematic inadequacy of hand cleansing, especially in regard to the subungual region of the nails, among this group. However, it is also possible that organisms persist on artificial nails because of properties intrinsic to the acrylic material of the nail.

An attempt was made in this study to control for nail length and the use of nail polish. Although a concerted effort was made to identify control HCWs with long, polished native fingernails, most volunteers in the control group wore their nails short and none wore nail polish. All volunteers who wore artificial nails wore their nails long and polished, resulting in a statistically significant difference in nail length between the 2 groups. We are therefore unable to comment on the role that nail length or nail polish play in increasing the colonization of artificial nails by potentially pathogenic bacteria and in the failure of hand cleansing to eliminate these bacteria. The tendency of artificial fingernails to harbor pathogens is likely the result of a combination of factors, including increased length, nail polish, and acrylic material, that are common to most artificial nails.

This study supports the contention of the Association of Operating Room Nurses that the use of artificial fingernails by HCWs might contribute to the transmission of pathogens to patients and their position that artificial nails should not be worn in the operating room. Hospital infection control committees should seriously consider the development of policies to restrict the use of artificial nails by HCWs who work in other high risk areas, such as intensive care units. In the absence of policies restricting the use of artificial nails, HCWs who choose to wear them should be educated about the tendency of artificial nails to harbor harmful bacteria and the difficulty in eliminating these bacteria with hand cleansing. The importance of conscientious hand cleansing should be stressed and proper techniques emphasized.

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**References**

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