Efficacy of three face masks in preventing inhalation of airborne contaminants in dental practice

LUIGI CHECCHI, M.D., M.S.; MARCO MONTEVECCHI, D.D.S.; ANNALISA MORESCHI, D.D.S.; FRANCESCA GRAZIOSI, M.D.; PAOLA TADDEI, Ph.D.; FRANCESCO SAVERIO VIOLANTE, M.D.

Face masks greatly reduce the risk of dental care workers' inhaling aerosols from patients' airways, which can contain pathogenic microorganisms related to diseases ranging from influenza to tuberculosis, meningitis or even severe acute respiratory syndrome. Such aerosols also contain large quantities of saliva, microorganisms, blood, tooth particles and restorative materials.[1-6] High-speed, air-driven dental handpieces and ultrasonic scalers produce large amounts of aerosol and spatter,[1-6] including visible and invisible particles, the latter ranging in diameter from 50 micrometers to submicron sizes.[7-9] Particulate matter in the 1- to 5-µm range is considered the most hazardous because it can reach the terminal bronchioli and nonciliated alveoli.[10,11] It has been reported that 95 percent of the particles measure less than 5 µm in diameter; 75 percent of these are contaminated by microorganisms.[12] Furthermore, the particles are concentrated mainly within 2 meters of the patient, where they easily can be inhaled by dental operators.[13,14] For these reasons, use of surgical face masks in dentistry has been advocated to protect clinicians from inhaling aerosols containing organic or

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ABSTRACT

ARTICLE 1

Background. Up-to-date studies are needed on the protection provided by face masks used by dentists. We assessed the relative filtering efficacy of two currently used surgical face masks (one a molded mask, the other a tie-on mask) and a certified personal particulate respirator, all made by a single manufacturer.

Methods. The authors sprayed bicarbonate particulate against a porcelain surface (representing the patient's mouth) and collected it via a mannequin head (representing the dentist's head) placed 40 centimeters away and a tube with two airflow rates (0.5 cubic meters per hour and 9 m^3/hour). They calculated the dry residue weight. They performed three separate runs for each mask and three runs with no mask at the two airflow rates with and without aerosol.

Results. With no mask (control), the authors recorded significant weight gains at both airflow rates with and without vaporization. With vaporization, the three masks were associated with different dry residue weights ($P < .03$ with the Kruskal-Wallis test at both flow rates), the respirator providing the lowest amount. The respirator provided an efficiency of 94 to 96 percent, compared with 90 to 92 percent and 85 to 86 percent for the molded and tie-on surgical masks, respectively.

Conclusions. These data provide independent evidence that a certified personal respirator can be more effective than high-quality surgical masks in dental settings.

Clinical Implications. Dentists should be aware that a certified particulate respirator can provide them with superior filtering protection.

Key Words. Surgical masks; infection control; particulate; respirators.

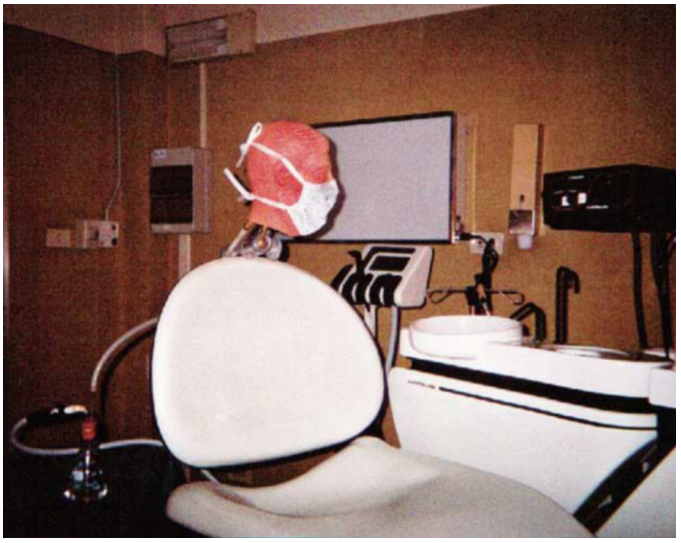

Figure 1. The experimental setting. Mannequin is shown with 1818 Tie-On Surgical Mask (3M ESPE SpA, Milan, Italy).

inorganic particulates, and also to protect the patient from possible contamination from the dental operator.

Various studies have been performed on the filtering efficacy of different general-purpose surgical face masks.[10,11,15-19] In 1971, Micik and colleagues[11] exposed 15 general-purpose surgical face masks to aerosols comparable to those generated during dental procedures and found that only those made of glass or synthetic fiber displayed relatively high filtering efficiency. In 1987, Pippin and colleagues[18] showed that even when masks were worn correctly, the airflow during inhalation could bypass the mask material, resulting in reduced filtering efficacy and an increased health risk for dental operators. Moreover, general-purpose surgical face masks are designed mainly to capture microorganisms in exhaled breath rather than to protect operators from airborne infections. Although specifically designed personal respirators now exist, to our knowledge, no study of efficacy has yet been reported in the scientific literature.

We performed simulations to compare the levels of protective efficacy against particles and aerosols of two surgical face masks in current use among many dental operators with those of a recently developed personal device: a facial filter protection (FFP) 2 disposable particulate respirator certified in accordance with standard EN 149:2001 as set by the European Committee for Standardization.[20]

METHODS

We performed simulations of a dental hygiene procedure involving an artificial bicarbonate aerosol in a vacant dentist's surgery room (Figure 1). Aerosols were formed using the Mini-Clean device (Castellini SpA, Bologna, Italy) with air pressure set to 6 to 7 atmospheres and water flow to 1 atm. We placed the aerosol distributor at a distance of 1 centimeter from a smooth porcelain surface that simulated the patient's mouth. We used a mannequin head to simulate the dentist's face and placed it at a distance of 40 cm from the porcelain surface. The mannequin's oral cavity was covered with latex and had one entry (mouth) and one exit (throat), connected to a 250-milliliter collection flask containing 50 mL of distilled water by a polytetrafluoroethylene tube 30 cm long and 1 cm in diameter that terminated well below the surface of the water. A vacuum pump (Cattani SpA, Parma, Italy) attached to the flask provided two possible airflow rates through the tube of 0.5 cubic meters per hour and 9 m^3/hour to simulate human breathing at rest and during exercise, respectively. We adjusted the airflow rates using the lock nut attached to the pump and calibrated by a flow meter. Using scanning electron microscopy, we found that the bicarbonate dust (Airflow Prophylaxis Powder, Electro Medical Systems, Nyon, Switzerland) was composed of particles of monosodium hydrogen carbonate (5-300 µm in diameter), silica particles (< 1 µm in diameter) and other (probably organic) particles of variable dimensions (10-20 µm in diameter).

We tested two types of surgical face masks, the 1818 Tie-On Surgical Mask and the 1942 FB Fluid Resistant Molded Surgical Mask (marketed internationally as the Aseptex Fluid Resistant Molded Surgical Mask 1800) (Figures 2 and 3) and a personal respirator (1862 Health Care Particulate Respirator and Surgical Mask) certified in accordance with European Committee on Standardization standard EN 149:2001 (Figure 4), all made by 3M ESPE SpA (Milan, Italy). We performed four sets of experiments with each of the three masks and in the absence of any mask (control): at the two airflow rates, each with and without vaporization of bicarbonate dust (0.5 m^3/hour and 9 m^3/hour). We conducted all sets of experiments in triplicate, with each individual run lasting 30 minutes. The room and equipment were cleaned thoroughly between each run. In sets of experiments involving vaporiza-