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Asbestos: a subtle carcinogen in the dental laboratory

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Risks encountered in dental practice have become the foci for a number of studies. Dangers associated with the inhalation of particulate matter (bacteria, viruses, enamel, dentin, calculus, and amalgam) from microbial aerosols,[1,2] produced during the use of high-speed rotary instruments, have been addressed. Investigations also have been conducted to establish and to define acceptable limits for levels of mercury vapor[3-5] and nitrous oxide[6-8] in the operating room.

Recently, there has been concern about asbestos fibers that emanate from the powder component of some periodontal dressings, as well as from liners for casting rings and crucibles.[9-10] This study was conducted to sample and to characterize particulate debris encountered in the use of asbestos in the dental laboratory.

Material and methods

A 3" segment of 1" wide ring liner was torn from a roll of asbestos* by each of two laboratory workers. Particulate matter, remaining on the thumbs and index fingers of the test subjects, was removed with the use of acetate tape. Additionally, the sites from which debris had been removed were resampled after the laboratory workers washed and dried their hands.

Two 3" strips of the asbestos were heated in a burnout furnace at 1,300°F for 45 minutes. The strips were cooled to room temperature in open air and torn by two volunteers. Sampling of particulate matter from the thumbs and index fingers of these individuals was accomplished as previously described.

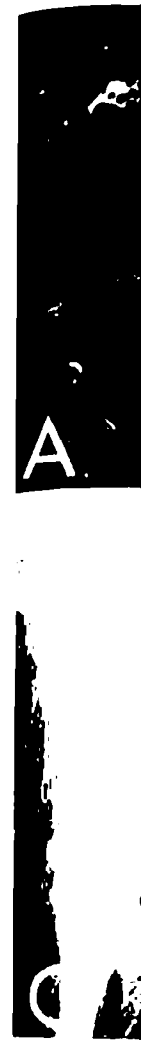
In a second approach, samples of debris were collected on acetate tape from a bench top on which 20 phosphate-bound investment molds had been broken from asbestos-lined metal casting rings. Additional particles were removed from a wall against which the bench was located, from the muffle of a furnace, from a casting machine, and from a drawer in which a roll of ring-liner had been stored.

The sampling tapes were sealed to aluminum stubs. The debris-containing side of each tape was coated with gold and palladium or carbon and examined with the use of a scanning electron microscope.† Photomicrographs of the collected matter were analyzed for determination of shape, size, and distribution of particulate components. Elemental constituents of selected carbon-coated particles were determined by energy-dispersive X-ray microanalysis.‡

Results

Scanning electron microscopic examination of the material collected from thumbs and index fingers showed aggregates of relatively straight, parallel fibers and single, randomly dispersed fibers (Fig. 1). The fibers, though fragmented, did not have axial cleavage. Diameters of the linear particles ranged from 0.10 to 1.0μm. Generally, fiber length exceeded 200μm. Morphologic differences between the particles that were broken from unheated and heated strips of the test material were not detected.

Dispersive X-ray analysis of selected particles showed that magnesium and silicon were the predominant constituents of the test material. However, small amounts of iron were also detected, as well as sulfur and calcium (Fig. 2). The approximate elemental composition of the fiber was as follows: magnesium, 45%; silicon, 40%; sulfur, 2%; calcium, 2%; and iron, 4%. Heat-



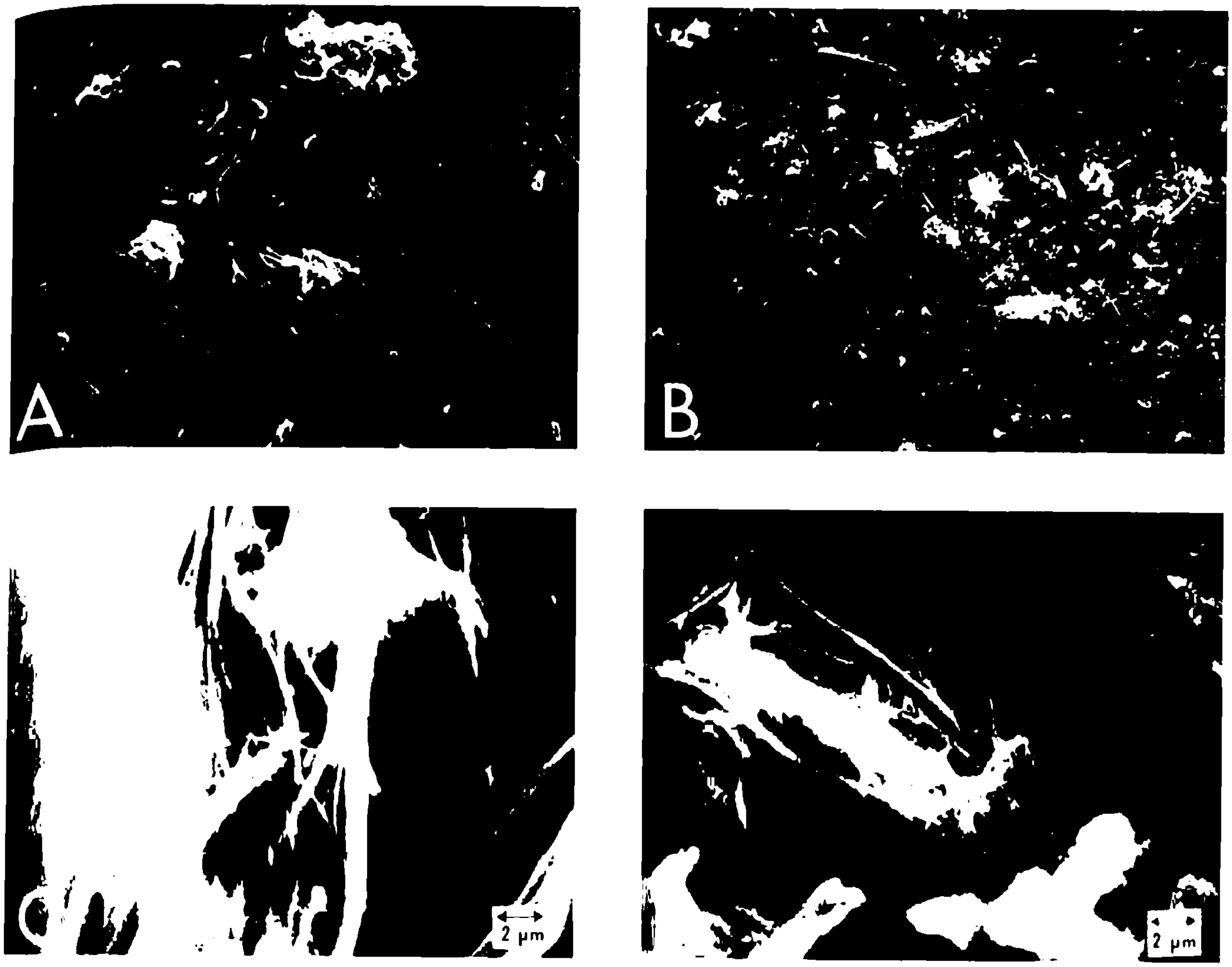


Fig. 1. *Photomicrographs of particulate matter removed from thumbs and index fingers of laboratory workers.* **A.** *Aggregates from dry, unheated ring liner (initial magnification, ×50).* **B.** *Aggregates from heated ring liner (initial magnification, ×50).* **C.** *Particles of dry, unheated ring liner (initial magnification, ×5,000).* **D.** *Particles of heated ring liner (initial magnification, ×5,000).*

ing at a conventional mold burnout temperature did not alter the elemental composition of the woven fibers.

Fibers were not detected in the particulate matter removed from the digits of washed hands. Occasional small, spheroidal, and plate-like particles found in one sample exhibited a broad range of elemental constituents (titanium, silicon, chlorine, potassium, calcium, and iron).

Samples of debris removed from the laboratory bench and wall contained fragmented slender particles (Fig. 3). Particles of similar configuration were recovered from the casting machine and from the storage drawer (Fig. 4). Results of analysis showed that these filamentous particles were composed of magnesium, silicon, sulfur, calcium, and iron in the same relative concentration as found on the fingertips. Particles that were detected within the muffle of the furnace were not fibrous; the ratio of length to diameter was less than 3 to 1. Constituents of these particles included silicon, phosphorous, calcium, and sulfur.

Discussion

Asbestos is a term used to identify any one of several minerals that can be crushed into fibers. However, a particular mineral substance, chrysolite, is the principle source of commercial asbestos.[11] Chrysolite is a hydrated silicate of magnesium; its approximate composition is 37% to 44% silicon dioxide, 39% to 44% magnesium oxide, 12% to 15% water, and 1% to 6% iron oxide. Analytical data indicated that the fibrous material examined in this study was chrysolite. The compositional features of the nonfibrous particles, removed from the fingers of washed hands and from the furnace muffle, inferred the presence of debris from refractory investment materials.

The occupational risk associated with asbestos exposure has been well documented in several studies.[12-16] In man, exposure to asbestos dust is associated with an increased incidence of tumors of the lung[17] and with pleural and peritoneal mesothelioma.[18] Asbestos fibers are subtle carcinogens that do not produce an obvious exposure-

Fig. 2. *Dispersive X-ray analysis of single fiber component (arrow) of asbestos casting ring liner.*

response relationship. Usually, a long latency precedes the onset of fibrogenic or carcinogenic activity, and the effects of repeated exposures over long periods are cumulative.[19]

The threshold limit value (TLV) below which asbestos would not adversely affect the health of man is not known. The current eight-hour time-weighted TLV for asbestos is two fibers per cubic centimeter of air[20]; however, this limit has not been evaluated with regard to its effectiveness in the prevention of asbestos-induced disease. Additionally, the mechanisms by which fibrous materials produce malignant disease are uncertain. It has been shown, however, that the degree of carcinogenicity is related to fiber size rather than to composition.[21] Data from animal experiments indicate that durable fibers less than 3μm in diameter and more than 20μm in length present the greatest hazard, and the fibers described in this report fall within this range of size.

The actual risk incurred in the use of dust-producing asbestos in dental laboratories is unknown. However, the potential for inhalation or ingestion of asbestos particles by dental laboratory workers appears to be greater than that for members of the general population. The need for rigorous standards of personal and laboratory hygiene in the handling of asbestos is obvious. For example, if hands are washed, as shown in this study, the material is effectively removed from the fingertips. Since it has been shown that cigarette smoking increases the risk of lung cancer in asbestos workers, smoking should be discouraged, especially within the working area.[22]

In view of the results reported here and in conformity with correct occupational health practices, the following protective measures are suggested for dental clinics:

1. All office and laboratory personnel should be informed of the potential danger of asbestos;
2. The storage and use of asbestos should be confined to a small area of the laboratory or to a small isolated working chamber;
3. Operatories and other offices should be isolated from the dental laboratory;
4. Face masks and surgical gloves should be worn when asbestos or asbestos-containing debris is handled;
5. Cutting instead of tearing asbestos should be encouraged;
6. Smoking or eating should be prevented in the dental laboratory;
7. Transmission of asbestos waste by sewage lines and air exhaust systems should be prevented to preclude discharge within the community environment.

Summary

Particles of debris emanating from asbestos-containing dental laboratory material were studied with the scanning electron microscope and X-ra

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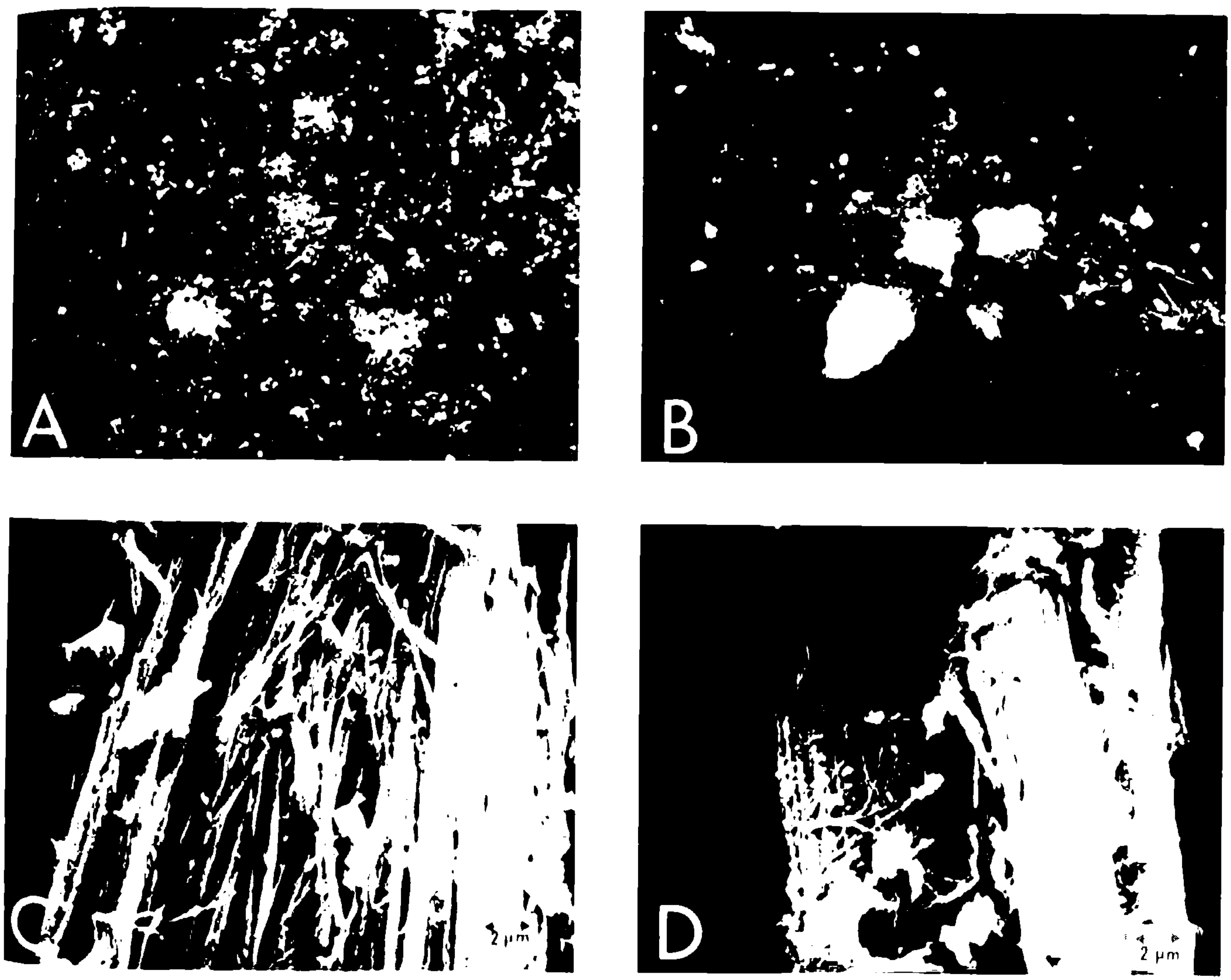

Fig. 3. *Photomicrographs of debris from laboratory bench top and laboratory wall.* **A.** *Full-field of bench top debris (initial magnification, ×50).* **B.** *Full-field of wall debris (initial magnification, ×50).* **C.** *Linear component of bench top debris (initial magnification, ×5,000).* **D.** *Bundle of linear components of wall debris (initial magnification, ×5,000).*

microprobe. The dimensions and composition of these particles suggest their potential as subtle carcinogens. With almost daily use of dust-producing asbestos in the dental laboratory, the improper handling of this substance could be hazardous to the health of dental personnel. It is recommended that high standards of personal and laboratory hygiene be used in the handling of asbestos.

Dr. Cutright is a commander with the U.S. Army Institute of Dental Research; Dr. Huget is chief of the Division of Dental Materials; and Dr. Brady is chief of the Department of Biophysics at the U.S. Army Institute of Dental Research, Walter Reed Medical Center, Washington, DC.

Acknowledgement

The views expressed herein are those of the authors and do not necessarily reflect the views of the United States Army or the Department of Defense.

**Ceramigold Investment, Whip-Mix Corp., Louisville, Kentucky.*
†Scanning Electron Microscope, model 1000, Advanced Metals Research Corp., Burlington, Massachusetts.
‡Energy Dispersive X-Ray Analyzer, model 707A, with EDIT II Software, EDAX International, Prairie View, Illinois

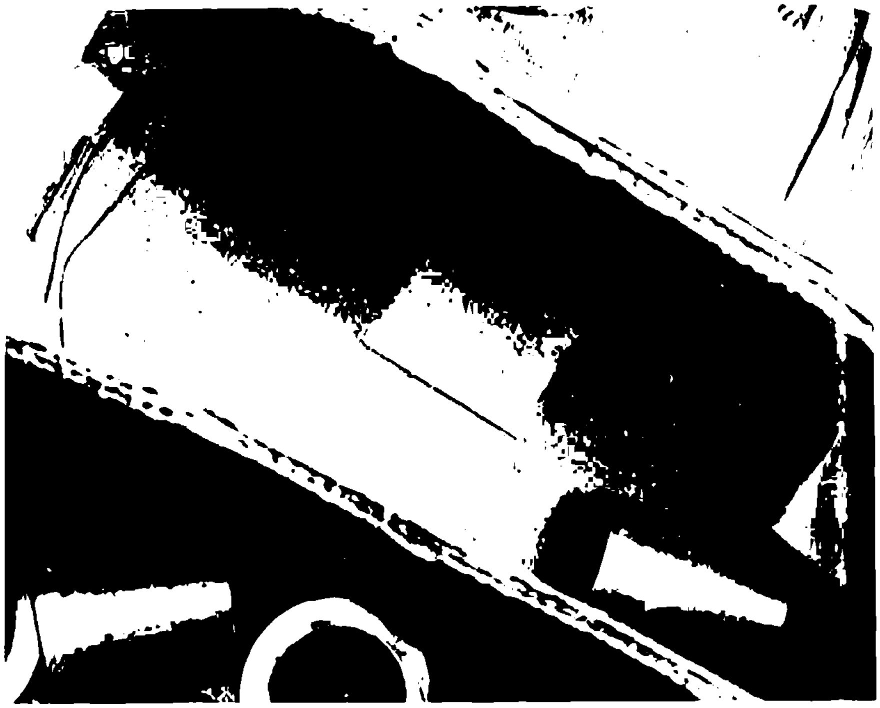

Fig. 4. *Fragmented debris from laboratory asbestos in storage drawer.*

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