Case Report

Malignant Mesothelioma Due to Asbestos Exposure in Dental Tape

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Although most cases of malignant mesothelioma of the pleura are caused by one or more readily recognized sources of exposure to asbestos, cases of the disease with more occult exposure occur, especially since asbestos has been used in over 3,000 products. Dental lining tape contained asbestos from the 1930s until at least the 1970s and was used in the lost wax method of casting crowns, bridges, and other metal dental prosthetic devices. We report six cases of pathology-verified malignant mesothelioma, mostly among dentists, following exposure to airborne dust from asbestos dental tape, which resulted in asbestos tort litigation. According to evidence available at present, chrysotile asbestos was the type of asbestos used in dental tape in the past in the United States, and the described cases followed relatively brief and intermittent exposure to this type of asbestos. These cases underscore the need for comprehensive exposure histories to determine exposure scenarios. Am. J. Ind. Med. 60:437–442, 2017. © 2017 Wiley Periodicals, Inc.

KEY WORDS: mesothelioma; dental tape; chrysotile; asbestos; dentist

INTRODUCTION

Given that the vast majority of cases of malignant mesothelioma of the pleura are caused by one or more specified sources of exposure to asbestos [Leigh and Driscoll, 2003; Marinaccio et al., 2010; Lacourt et al., 2014], it is both feasible for, and incumbent upon, health care providers to identify these sources. Many of the principal sources of asbestos exposure are well-known and readily recognized—insulation, cement, sealing materials, textiles, brakes, and others. However, asbestos was used in over 3,000 products in the past, so that cases of malignant mesothelioma are likely to occur following less common uses of asbestos, which may elude the clinician taking a history. It is nonetheless important to alert clinicians to these sources, both to enhance decision-making in diagnosis and screening for asbestos-related diseases and to communicate the breadth of the continuing asbestos disease epidemic.

Beginning in the 1930s, asbestos was used in dentistry as a liner during fabrication of crowns and other metal prostheses [Sichletidis et al., 2009]. To our knowledge, there is a single published case report in the English language of a mesothelioma in a dentist [Reid et al., 1991]. We present six cases of individuals with malignant mesothelioma who were exposed to asbestos in the 1960s to the 1970s while using asbestos-containing dental tape to fabricate dental crowns and bridges, or, in one case, using dental lining tape to cast jewelry. All six were diagnosed with malignant mesothelioma, and all died from the disease.

The cases were referred to the authors (SM and JM) for medico-legal evaluation as part of tort litigation. All information was obtained from medical records and legal depositions of the cases (and, in one case, also a brother who was a dentist). In every case, a pathology report confirmed the diagnosis of malignant mesothelioma. Informed consent and Institutional Review Board review were not obtained in these

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cases, because deceased individuals are not considered human research subjects subject to Institutional Review Board review.

CASE PRESENTATIONS

Case 1

TU was a 70-year-old dentist with a history of hypertension, hyperlipidemia, and gout when he developed severe coughing episodes and syncope in April 2014. A chest x-ray showed a large left pleural effusion, and a chest CT scan showed near complete opacification of the left chest. Numerous areas of calcified pleura were seen in the lower posterior left chest. Repeat thoracenteses showed atypical mesothelial cells, and a PET scan demonstrated numerous areas of increased uptake in the left chest. TU underwent left video-assisted thoracoscopic surgery and parietal pleurectomy in late May 2014. The surgeon noted the presence of "scattered pleural plaques consistent with some prior asbestos exposure." Pathology review, including immunohistochemical stains, confirmed the presence of a malignant mesothelioma of the pleura. TU received six cycles of pemetrexed and cisplatin chemotherapy and subsequently participated in a clinical vaccine trial, followed by additional chemotherapy. His health deteriorated, and he died from malignant mesothelioma in October 2015.

TU attended dental school in the United States between 1970 and 1974. He fabricated crowns and bridges using the lost wax method of casting. He recalled making 114 units during dental school. He described that he tore the dental tape by hand, which he associated with producing some dust, and placed it in the casting crucible. After heating, he scraped out the lining material, creating airborne dust. He later swept up the debris that landed on his work table by hand. After dental school, TU worked in a dental practice where he continued to make dental prostheses using the same lost wax method and dental tape, though less frequently. TU's only other potential exposure to asbestos was when he applied and sanded some joint compound in a limited renovation of his own home in 1976–1977.

Case 2

In September 2004, a 55-year-old dentist (FX) presented to a physician with dyspnea, fever, chest discomfort, cough, and wheezing. He had a history of a retroperitoneal liposarcoma, which was successfully resected in 2001. A chest x-ray in September 2004 showed a large right pleural effusion, and FX underwent thoracentesis at the local Emergency Department, cytology review indicated no evidence of malignant cells. A chest CT showed a likely pleural mass. FX's symptoms worsened, and he had a PET scan, bronchoscopy, and thoracoscopy with talc pleurodesis. Thoracoscopic biopsy was positive for malignant mesothelioma of the right pleura, biphasic type. In late September, FX started combination chemotherapy with pemetrexed and cisplatin. In November 2004, he underwent an extrapleural pneumonectomy followed by adjuvant radiation in late December 2004. His condition worsened during the ensuing months, and FX died from malignant mesothelioma of the pleura in June 2005.

FX's was a lifelong practicing dentist. He attended dental school from 1971 to 1975, where he produced approximately 100 crowns using the "lost wax technique" employing asbestos-containing tape as the lining material. He ripped or cut the dental tape and discarded the debris from the casting work. He reported that this work was dusty, from his own and also from other student use of dental tape. After graduating from dental school, he no longer performed crown fabrication and had no other known asbestos exposure.

Case 3

TZ was a 55 year-old practicing healthy dentist who developed fatigue, fever, and chills in the spring of 2003. Past medical history was notable for hypertension and benign prostatic hypertrophy. Due to significant nocturia, an abdominal CT scan was performed in June 2003, showing an abnormality of the left inferior pleura. A chest CT was significant for extensive pleural thickening along the medial pleural surface of the left chest. He underwent a thoracotomy, which revealed a soft necrotic pleural tumor, and pathology review of biopsy material demonstrated a malignant mesothelioma of the pleura, epithelial and anaplastic type with pleomorphic giant cells. TZ underwent a left extrapleural pneumonectomy in July 2003. He then received radiation treatment and chemotherapy, initially with gemcitabine and carboplatin and subsequently with pemetrexed and carboplatin. He developed atrial flutter, depression, anxiety and significant chest pain. TZ died from malignant mesothelioma of the pleura in May 2004 at the age of 56.

TZ attended the same dental school as Case 2 from 1969 to 1973 and produced multiple crowns using asbestos-containing tape for lining the casting rings during the second half of dental school. TZ recalled that both ripping the liner and using a hammer to break the crown out of the hardened investment material generated visible dust. He reported that the work laboratory was dusty from his work and that of his classmates, and he had to clean up the dust with a handheld broom. At one point in school, he did this work on a daily basis for 2 months. After graduating from dental school, he reported no further asbestos exposure.

Case 4

BT was a 59-year-old dentist who developed a fever, weight loss and fatigue in 2003. A CT scan of the chest

showed a suspicious right upper lung mass. A CT-directed biopsy of the chest mass was, on pathology review, positive for malignant mesothelioma, biphasic type, which was confirmed by results of immunohistochemical staining. In September 2003, BT underwent radical extrapleural pneumonectomy, resection and re-construction of the right side of the pericardium and the right diaphragm, Tumor nodules were seen on the visceral and parietal pleura and the right diaphragm. The surgeon commented in the operative report on an "apparent benign pleural plaque," which was seen but not removed. Pathology review of obtained tissue confirmed the presence of malignant mesothelioma in the pleura, diaphragm, pericardium, and lung parenchyma. He did poorly in the months following surgery and died of malignant mesothelioma of the pleura in January 2004.

BT attended dental school in the United States between 1964 and 1969. Beginning in his first year, BT used asbestos-containing dental tape in making crowns, inlays, and bridge castings. This involved tearing asbestos tape, pressing the tape in the process of making the mold, and removing and discarding the tape after casting. Pictures of the laboratory of the dental school in 1966 confirmed that dozens of students were working with dental lining tape within a few feet of each other at laboratory benches. BT also used asbestos tape in doing dental laboratory work in a laboratory at a dental fraternity house. He had no subsequent exposure to asbestos-containing products.

Case 5

In June 2006, 69 year-old UM developed right-sided chest pressure, dyspnea on exertion, and weight loss. He had a chest x-ray in November 2006, which showed a right pleural effusion and an accompanying infiltrate. Chest CT scan on the following day showed a right pleural effusion with multiple pleural nodules in the right upper chest, atelectasis, and pleural thickening. In December 2006, results of a thoracentesis suggested a possible malignancy. UM then underwent a thoracotomy, but the entire tumor could not be removed due to invasion of the chest wall. Pathology review of surgical tissue confirmed the diagnosis of malignant mesothelioma of the pleura. In late January 2007, he began treatment with pemetrexed and cisplatin for six cycles and received radiation therapy, which was completed in August 2007. UM died in May 2010.

From 1967 to 1973, UM attended dental technician school and used asbestos tape to line casting rings during crown and bridge production. He used scissors or an Exacto knife to cut the asbestos tape, which was supplied in boxes that contained dust. He used asbestos-containing gloves to remove casting rings from the ovens. He had daily exposure to asbestos in the laboratory setting during his years at dental technician school. There were approximately 75–100 other technicians in the laboratory room. He recalls sweeping his work area, which he described as being dusty. UM had other possible sources of exposure to asbestos. UM's father worked in shipyards for approximately 5 years in the 1940s. In high school chemistry laboratory, UM recalled potential exposure to asbestos sheets on the tripods of Bunsen burners.

Case 6

HK was a 49-year-old woman with a history of hysterectomy and salpingo-oopherectomy who was hospitalized for small bowel obstruction in August 2005. A CT scan of the abdomen showed omental caking. Core needle biopsy of the tumor underwent pathology review with the diagnosis of malignant mesothelioma of the peritoneum, epithelial type, as confirmed by results of immunohistochemical staining. She sought treatment at a university hospital, where pathology review confirmed the mesothelioma. She received chemotherapy with cisplatin and pemetrexed and subsequently underwent laparatomy, debulking of tumor, omentectomy, and small bowel resection in October 2005. Pathology review of tissue obtained at surgery again supported the diagnosis of malignant mesothelioma of the peritoneum. HK received chemotherapy during the 7 months following surgery, but suffered progression of the mesothelioma and died in November 2006.

HK was a silversmith. She had received undergraduate and graduate degrees in art in 1978 and 1981. For 1 year in college, she cast jewelry using the "lost wax method" of casting, lining the sides of the crucible with asbestos dental tape prior to casting. After casting, she scraped out the asbestos tape, creating airborne dust. She also used this asbestos tape to line a surface on which to solder jewelry, and she reported that the tape deteriorated and became dusty after repeated use. She swept with a dry broom in the art classroom where casts were fabricated. HK additionally used asbestos boards on which she soldered as a student and recalled that these boards eventually broke after repeated use. HK did not subsequently use asbestos-containing materials as an artist or have any other exposure to asbestos after receiving her academic degrees.

DISCUSSION

Malignant mesothelioma, the signal cancer of asbestos exposure, is known to occur following limited exposure to asbestos. Or, as succinctly expressed in a consensus report on attribution of asbestos-related diseases two decades ago: "an occupational history of brief or low-level exposure should be considered sufficient for mesothelioma to be designated as occupationally related" [Helsinki, 1997]. Numerous epidemiological studies have provided quantitative estimates of

the increased risk of malignant mesothelioma in relation to relatively modest occupational and non-occupational exposures to asbestos [Iwatsubo et al., 1998; Agudo et al., 2000; Magnani et al., 2000; Rödelsperger et al., 2001; Lacourt et al., 2014; Markowitz, 2015].

The exposure to asbestos-containing dental tape described in these case reports was episodic, limited in degree, and, in most of the cases, occurred over a few years only. In all six cases reported herein, dental lining tape was their exclusive (four cases) or primary (two cases) source of exposure to asbestos. Each case personally described use of the dental tape that created visible airborne dust and worked in proximity to other students who were performing similar work, adding to the asbestos exposure of the index cases. Latency between onset of exposure to asbestos and diagnosis of mesothelioma was typical, ranging from 28 to 44 years.

Asbestos was used in dental lining tape from the 1930s until at least the 1970s. The dental lining tape was used to cast metal dental prostheses and contained chrysotile asbestos in the United States [Cutright et al., 1980; Davis, 1987]. In the early 20th century, dentistry began to employ the "lost wax method" of casting dental prostheses. This method involves making a positive reproduction of the desired object in wax, placing it in a ring or crucible, and then surrounding the wax object with refractory or investment material. The inner surface of the crucible or ring was lined with asbestos lining tape prior to casting at a high temperature. Metal is injected into the mold and replaces the wax. After casting and cooling, the crucible is opened, the lining and refractory material chipped or scraped off, and the desired object recovered. Jewelry production subsequently adopted this method of producing rings and other items.

Only one case of malignant mesothelioma attributable to dental materials containing asbestos has been reported in the English language published literature [Reid et al., 1991]. Reid et al. [1991] reported a 60-year-old dentist with malignant mesothelioma of the pleura whose lung tissue showed 0.7×10^6 crocidolite fibers per gram dry lung, which was elevated compared to the general population. No other source of asbestos exposure was identified.

Sichletidis et al. [2009] reported finding typical asbestos-related calcified pleural plaques among three lifelong dentists who had previously used asbestos-containing dental tape to cast dental prosthetic devices.

Prior studies of chronic respiratory disease and cancer among dental personnel are complicated by multiple exposures, including silica, beryllium, and chromium-cobalt [Choudat et al., 1993; Radi et al., 2002]. Notably, Radi et al. [2002] studied 134 dental technicians and 131 non-exposed controls and found an association between report of prior exposure to asbestos and the presence of radiographic small lung opacities with profusion >1/0. Choudat et al. [1993] found predominantly small linear, irregular opacities (s or t, according to the ILO scale) on chest films of dental technicians, which increased in prevalence with increasing duration of employment as a dental technician.

Nayebzadeh et al. [1999] examined lung tissue of a dental technician with silicosis and hard metal pneumoconiosis. Transmission electron microscopy and energy dispersive spectrometry analysis of lung biopsy material showed 12,600 chrysotile fibers (<5 μ) per mg dry lung and 5,440 chrysotile fibers (>5 μ) per mg dry lung, which was 1.5 to two times higher than the pulmonary chrysotile fiber burden found among Quebec miners and millers and 24–32 times higher than that of the reference population. No other types of asbestos fibers were described. The authors concluded that the measured concentration of asbestos fibers was indicative of occupational exposure to asbestos and, given the absence of any history of asbestos exposure in work other than dental work, the patient's asbestos fiber burden was due to his work in the dental laboratory [Nayebzadeh et al., 1999].

Mortality studies of dentists conducted over the past several decades do not report deaths from malignant mesothelioma [Eriksson et al., 1998; Shimpo et al., 1998; Simning and van Wijngaarden, 2007; Koifman et al., 2014]. However, studies that relied on ICD coding prior to 1998, when ICD-10 was adopted, did not have a code specific for malignant mesothelioma to use. In addition, a relatively low but nonetheless elevated risk of malignant mesothelioma would be difficult to detect unless the study included a large number of deaths. Finally, if use of asbestos-containing dental tape was highest in the 1960s and 1970s, the resultant cases of malignant mesothelioma would not be expected until 2000 or after and would not have been recorded in studies to date, which describe mortality patterns prior to 2000.

There has been little published research assessing asbestos exposure in dental casting operations. Brune and Beltesbrekke [1981] used light microscopy to measure airborne asbestos fiber concentrations during dismantling of a finished mold in a dental workroom. In short-term air samples, they found levels of 21 and 27 asbestos fibers/cm^3 at 12 inches from the mold at the time of dismantling. Levels declined to 2 fibers/cm^3 after 10 min following dismantling [Brune and Beltesbrekke, 1981]. Davis used phase contrast microscopy to measure airborne asbestos fiber concentrations in three samples over 30 min periods following tearing, placement, and removal of dental tape, and found breathing zone concentrations of 0.065–0.092 fibers/cm^3 [Davis, 1995]. Sichletidis simulated the dental casting operation in 2009 and found 0.008 chrysotile asbestos fibers/cm^3 during a single 4 hr sampling period, using phase contrast microscopy [Sichletidis et al., 2009].

Notably, according to evidence available at present, dental tape used in the United States contained chrysotile fiber,

rather than the commercial amphiboles [Cutright et al., 1980; Davis, 1987]. The duration, frequency, and likely intensity of asbestos exposure for the cases reported herein indicated a likely modest cumulative exposure to chrysotile but no exposure to the commercial amphibole varieties of asbestos except for the possible presence of a small amount of tremolite in commercially used chrysotile. These findings add to current evidence that exposure to chrysotile asbestos at relatively low exposure levels, can cause malignant mesothelioma.

In the setting of a known causal link between an exposure and disease, especially one with as close a link as exists between asbestos and malignant mesothelioma, a case series can establish that a particular set of asbestos exposure conditions can cause malignant mesothelioma [Checkoway et al., 2004]. Given the absence or near absence of alternative exposures to asbestos, the finding of the characteristic latency period between onset of asbestos exposure and diagnosis of malignant mesothelioma, and pathologic confirmation of disease, the conclusion that the dentists and jeweler reported herein developed malignant mesothelioma is justified. Moreover, the cases described herein used the asbestos-containing dental tape in different schools and different exposure settings, providing evidence that the exposure to asbestos through manipulation of dental tape was fairly robust. Sporadic cases of malignant mesothelioma in other atypical occupations are likely to occur in the foreseeable future and may be readily detected by taking a thorough occupational history.

AUTHORS' CONTRIBUTIONS

SM and JM participated in the following: a) conception or design of the work; b) the acquisition, analysis, or interpretation of data; c) drafting the work and revising it critically for important intellectual content; d) final approval of the version to be published; and e) agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ETHICS APPROVAL AND INFORMED CONSENT

Informed consent and Institutional Review Board review were not obtained in these cases, because deceased individuals are not consider human research subjects subject to Institutional Review Board review.

DISCLOSURE (AUTHORS)

The authors have served as expert witnesses in cases involving asbestos tort litigation.

DISCLOSURE BY AJIM EDITOR OF RECORD

Rodney Ehrlich declares that he has no conflicts of interest in the review and publication decision regarding this article.

DISCLAIMER

None.

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