*Lawrence Gettleman,*[1] *D.M.D., M.S.D.; R. F. Carr,*[1] *D.D.S.; and E. E. Herschaft,*[1] *D.D.S.*

# Identification of a Foreign Body Using Energy Dispersive X-Ray Analysis

**REFERENCE:** Gettleman, L., Carr, R. F., and Herschaft, E. E., **"Identification of a Foreign Body Using Energy Dispersive X-Ray Analysis,"** *Journal of Forensic Sciences,* JFSCA, Vol. 26, No. 1, Jan. 1981, pp. 58-63.

**ABSTRACT:** A foreign object, presumably swallowed during a dental appointment, was recovered by using an esophagoscope and thought to be a piece of dental impression material, probably alginate. It was identified as being of nondental origin by means of visible light and scanning electron microscopy (SEM), the latter coupled to an energy dispersive X-ray analyzer. Histologic examination revealed some amorphous crystalline material surrounded by parakeratin and exfoliated squamous cells. The material was essentially radiolucent. A known dental alginate impression material contained diatomaceous earth filler (siliceous shells of diatoms), but no microscopic symmetrical figures were seen in the foreign body. After dehydration, both materials were carbon-coated and observed in an SEM at 20 kV at magnifications up to 2000×. The spectrum of secondary X-rays produced by the scanning electron beam revealed only magnesium in the foreign body and mostly silicon in the dental alginate. There are no known dental products that contain magnesium as the only inorganic ingredient and so the foreign body is believed to be not of dental origin. The patient may have had an antacid or laxative having magnesium as a major ingredient in the stomach, and this may have been refluxed from the stomach after stimulation of the normal gag reflex during the dental procedure.

**KEYWORDS:** odontology, radiography, foreign bodies, dental impression material, dental alginate material, magnesium compounds, scanning electron microscopy, energy dispersive X-ray analysis

A foreign body was referred to the Louisiana State University School of Dentistry, Department of Biomaterials, by a practicing dentist in the New Orleans area for identification. The apparent sequence of events leading to recovery of the foreign body were as follows: During a dental appointment in which an impression was being made, the patient apparently ingested some of the impression material and gagged. The material was not recovered through normal reflex action, and the patient was referred to the emergency ward of a local hospital. At that time, the foreign body was recovered by using an esophagoscope and was sent to the pathology department for identification. The gross description was of a "chalk-stained friable material." Histologic sections were made, and the foreign body was described as consisting of "amorphous debris and crystalline material."

Presented at the 32nd Annual Meeting of the American Academy of Forensic Sciences, New Orleans, La., 20-23 Feb. 1980. Received for publication 18 April 1980; accepted for publication 12 June 1980.

[1]Associate professor of biomaterials and head of the department; associate professor of pathology; and associate professor of oral diagnosis, medicine, and radiology, respectively, Departments of Biomaterials, Oral Pathology, and Oral Diagnosis, Louisiana State University School of Dentistry, New Orleans, La. 70119.

The foreign body was forwarded to our laboratory and the following evaluation was carried out.

**Procedures**

Reflected light examination in bright- and dark-field illumination did not identify the object. The object was then embedded in paraffin and was barely visible as an unstained specimen.

Dental radiographs were taken in two orientations at various X-ray intensities to determine if radiopaque material was present.

The specimen was remounted in a microtome block compatible with our equipment, and new histologic sections were made and stained with hematoxylin and eosin. Samples of three brands of dental alginate impression material were also submitted and sectioned for comparison with the foreign body.

Further examination was performed by removing the embedding wax in chloroform and alcohol and remounting the specimen on an aluminum stub and coating it with vaporized carbon (to carry off surface charges). A piece of one of the known alginate impression materials was also included on the stub.

**Observations**

The specimen in the microtome block appeared to consist of two pieces of a white irregular material, approximately 4 by 4 mm and 2 by 3 mm. The dental radiographs showed that this specimen was only very slightly radiopaque. The plastic block to which the specimen was affixed appeared to be more opaque to X-rays than the specimen itself.

The following report was received from our oral pathologist after the histologic examination had been completed:

> There were fairly well-preserved squamous cells, parakeratin, and nonhomogeneous matrix of material that was variously granular, refractile, and nonstaining or irregular, hyaline, and dark pink. In addition, fibrillar blue-staining material was occasionally seen within the agglomerate. A fragment of regularly arranged (parallel) spindle cells with pink-staining cytoplasm was noted. This had the morphology of smooth muscle. One focus of red blood cells was noted [see Fig. 1].
>
> The three samples of dental alginate material had in common the presence of refractile small particles, many of which were rod shaped or honeycombed. Presumably these particles are fragments of diatoms and were not seen in the foreign body specimen [see Fig. 2].
>
> Since the particles were not present in the foreign body, one may conclude that the amorphous material in the specimen is either 1) not alginate or 2) possibly alginate, but if so one which lacks diatomaceous filler.

The small particles of the foreign body that were recovered were thought to be the crystalline material described in the pathology reports. They were subjected in vacuum to a scanning electron beam but could not be identified from their appearance (Fig. 3). The excited X-rays from the sample were displayed as a spectrum for the identification of elements. The spectrum detects elements heavier than sodium and the predominant peak in the spectrum of the unknown object was identified as the K$\alpha$ line of magnesium; it is the only element that was present in the sample (Fig. 4). A similar spectrum was obtained from both particles on the stub. The known sample of dental alginate impression material was also scanned, and the predominant peak that was identified was the K$\alpha$ line of silicon (Fig. 5).

**Results and Discussion**

The foreign body, which was thought to have been swallowed, was an accumulation of sloughed squamous cells, smooth muscle cells perhaps from foodstuffs, and the granular

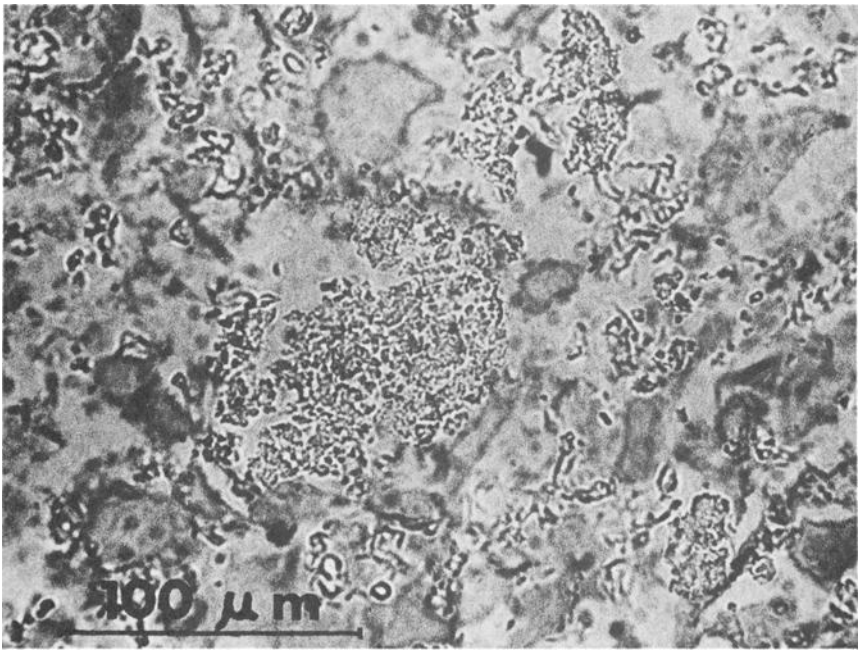


FIG. 1—*Histologic section of unknown foreign object (hematoxylin and eosin stain).*

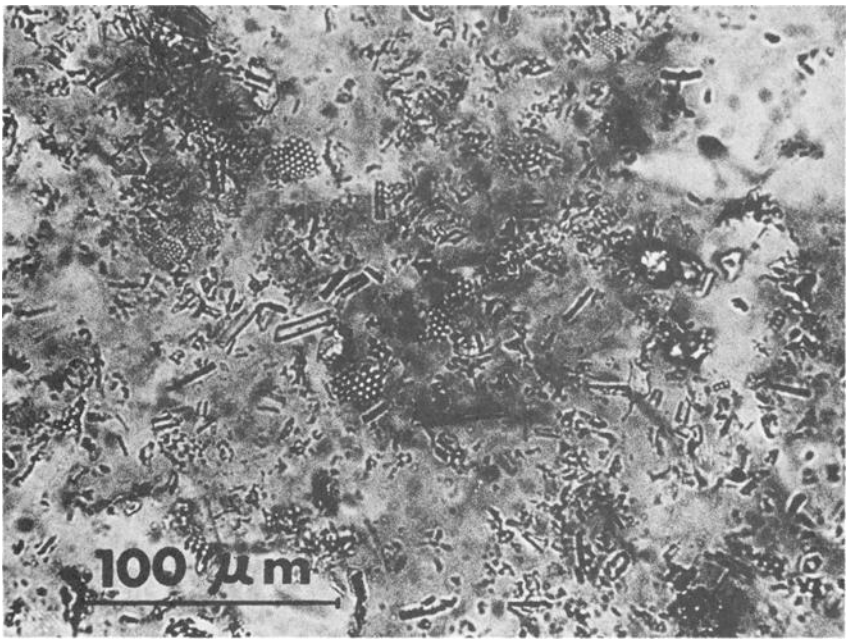


FIG. 2—*Histologic section of Supergel (Bosworth) dental alginate impression material (hematoxylin and eosin stain).*

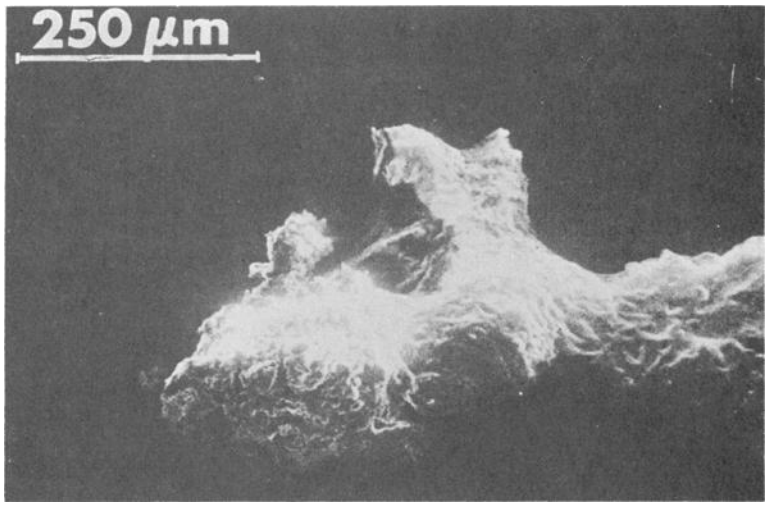


FIG. 3—*Granule from unknown foreign object seen in the scanning electron microscope.*

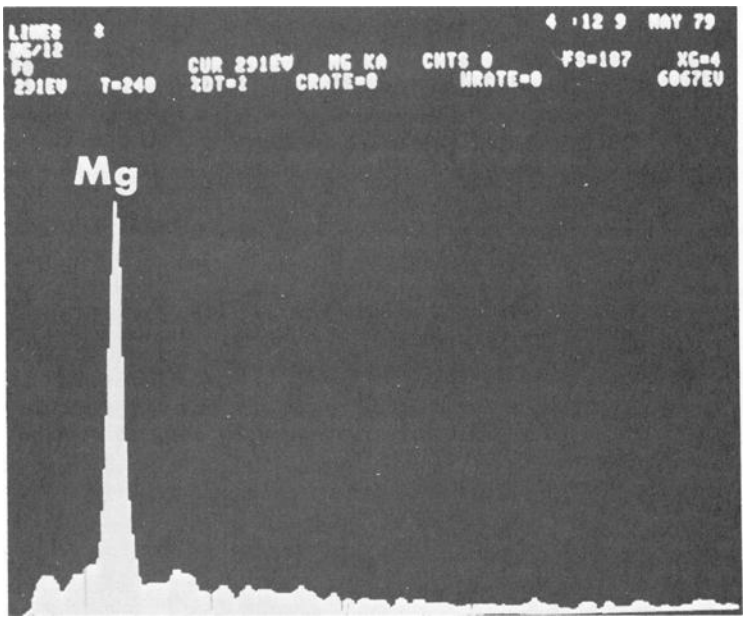


FIG. 4—*Energy dispersive X-ray spectrum from the unknown foreign object. X-ray intensity (counts per minute) is on the ordinate; energy from 291 to 6067 eV is on the abscissa. Note the single magnesium peak.*

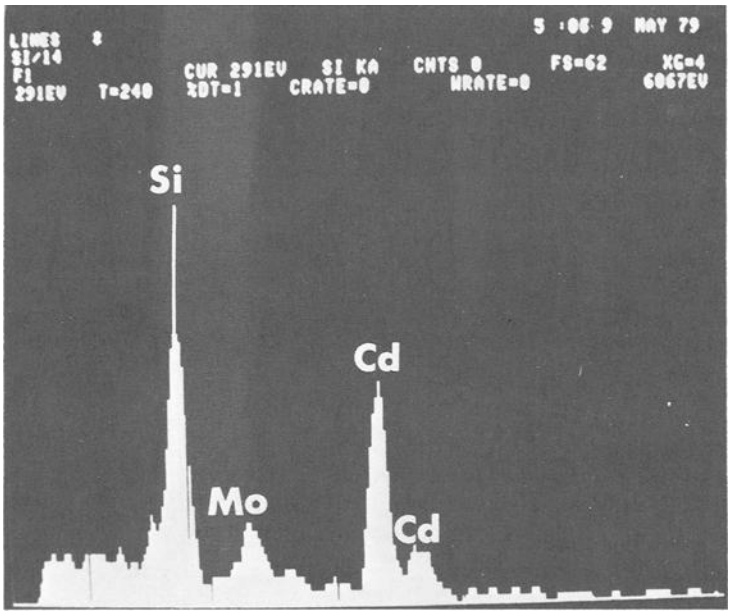


FIG. 5—*Energy dispersive X-ray spectrum from dental alginate impression material. The left-hand peak is silicon; the other three peaks are molybdenum, cadmium, and antimony or cadmium, respectively. Note dissimilarity to spectrum in Fig. 4.*

crystalline foreign material. This material was only slightly opaque to X-rays and consisted entirely of magnesium or elements lighter than sodium in atomic weight.

It is our opinion that, within reasonable scientific certainty, the foreign body material is not dental alginate impression material; that opinion is based on the material's light and electron microscopic appearance and its chemical dissimilarity to dental alginate. Diatomaceous filler, which is a major constituent of most, if not all, dental alginates, is composed of the shells of microorganisms and is made of silica. No silica was found in the foreign body, but magnesium was. The foreign body is apparently not of dental origin because there are no dental products known to consist mostly or entirely of magnesium or magnesium products.

It is our opinion that some of the magnesium present in the patient's stomach may have been ingested as an antacid or as a laxative beforehand rather than during the dental appointment. This material may have then refluxed from the patient's stomach if the patient's normal gag reflex had been stimulated during the impression-making procedure.

The conclusive evidence in this case resulted from the use of equipment that is becoming more common in research laboratories and medical centers. It consists of a scanning electron microscope coupled to an element-detecting device [*1–3*]. The most popular devices consist of energy dispersive X-ray analyzers, although wavelength X-ray analyzers also exist. The principle behind the operation of this equipment is as follows: The sample is placed in an evacuated column and bombarded by a beam of electrons focused to a point less than 1 $\mu$m in diameter. As the sample is scanned with electrons, the backscatter or secondary electrons emitted from the sample are detected and displayed in a raster on a cathode-ray tube. Great magnifications with sizable depth of field can be achieved with this method so that black and white photographs of scanning electron images have great dramatic intensity. The penetration of the electrons into the sample energizes certain electrons present in the irradiated atoms, causing the electrons to jump from one orbit to another. These electrons spon-

taneously decay to their ground state and emit an X-ray at characteristic energies for each element. For elements with many orbital electrons a small shower of characteristic X-rays can be emitted. When detected with an appropriate detector, the energy or the wavelength of these X-rays leaves a signature for the particular elements involved. The identification of these elements (approximately 100 elements can be detected) is then done through known standards of wavelength or energy; such identification can be very conclusive. Quantitative identification of the elements is also possible but a more complicated analysis is necessary.

The use of such equipment is to be encouraged in forensic science work because a positive identification is possible with very small amounts of material. Known standards are desirable to make the identification conclusive.

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Address requests for reprints or additional information to
Lawrence Gettleman, D.M.D.
4300 Houma Blvd. Suite 305
Metairie, La. 70002