Is There A Renewed Trend of

Radioactive Compounds
In
Dental Materials?

Ulf Bengtsson
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Radioactive Compounds in Dental Materials.

Abstract.
In order to mimic the fluorescence of human dentine radioactive compounds including both natural and depleted uranium have been used in artificial teeth and ceramic powders. This use of uranium has been going on at least since 1925.

Strong indications point at a new and accelerated use of radioactive compounds in other dental materials. Especially thorium but also uranium and perhaps others might have been added to some of the new composite resins dominating the market today. The main reason is to achieve the necessary X-ray opacity. Non-radioactive alternatives do however exist.

When used as a fluorescent agent in artificial teeth and ceramic powders uranium must not exceed 0.03% by weight according to the only standard regulating radioactive compounds in dental materials (USA). This standard explicitly says that the limitations are only valid for uranium in dental porcelain. When used as radiopaque agents in dental composites it will be necessary to add radioactive or other heavy metals up to a considerably higher level, perhaps as high as 10% or more.

In one scientific article an acrylic resin for polymeric appliances is proposed to contain 11 – 14% of uranium. It is uncertain whether this has materialized into a marketed product.

One patent describes a dental cement containing uranium in order to render the product X-ray opacity.

No relationship between radioactive dental materials and cancer has been established. In fact it has not even been investigated. No scientific article discussing a possible trend towards modern radioactive dental materials has been found.

The use of radioactive compounds in dental materials has to be investigated. It has to be established if radioactive fillings are used and if so, the problem has to be quantified. Dental materials are ground and polished in the patients’ mouth, sometimes with unintentional damage to the oral mucousa thus resulting in an imbedding of dental material. This possibility has to be taken into account when examining the biocompatibility of these dental materials. The possibility that the patient is swallowing radioactive particles due to teeth grinding or dental treatment has to be addressed. Possible inhalation of radioactive compounds by patients, technicians and dentists has to be taken into account.

The use of intentionally radioactive implants where radioactivity is not used for its therapeutic effects but for technological reasons alone has to be carefully reviewed.
**Ingredients of dental materials.**

It has been argued that the ingredients of dental materials should be openly declared, as is the case with drugs. Many have been in favor of such a listing. Dental trade in Sweden has for example taken the initiative to declare different dental products and their ingredients – the database DentMR found on the Internet at:
http://www.dentmr.dentalhandel.se/

Due to very imprecise listing of ingredients and very poor quality of information this database is however of limited use to professionals. This especially holds true for the more complex materials such as composites.

Cahn et al say (1):
“The components of composite resins are often disclosed by manufacturers in general terms, but significant information may only be attained by chemical analysis.”

There are only two valuable sources of information openly available – scientific articles and patents.

Scientific articles are of course of value when published. Especially so when showing results of chemical analysis. It should however be pointed out that dental science has an ethically troublesome situation because of the heavy involvement with the dental industry. Most dental materials manufacturers are members of several worldwide dental scientific organizations making monetary contributions to their activities. These dental organizations own a number of scientific journals and counts most dental scientists and many governmental officers in the field of dentistry as members. Members from the dental industry hold official positions in dental scientific organizations. Few, if any, scientific areas shows such a heavy organizational amalgamation with industry as dental science does. In 1964 The American Dental Association Board of Trustees established The American Dental Association Health Foundation, ADAHF. At present ADAHF holds some 60 patents and a number of these deals with composites. New products are developed and patents are licensed to dental manufacturers on commercial grounds. None of the ADAHF patents mentions *uranium* or *thorium*.

The heavy organizational amalgamation between dental science and industry can be further studied at: http://vest.gu.se/~bosse/ybftBEN95a.html

Patents are often overlooked as a source of information. Patents are legal documents and therefore of special interest. Information otherwise regarded as secrets of the trade can be found there.

It should be pointed out that the fact that a product has received a patent does not mean that this particular product can be found on the market. However, background information in the patents for the proposed invention often reveals ingredients of products.
currently on the market. This is for example true in the case of radioactive compounds in dental composites.

**Radioactive compounds in dental ceramics.**

The use of radioactive compounds in dental ceramics is one of long standing. In these materials radioactive ingredients are used for purely cosmetic reasons alone. Human dentine is weakly fluorescent and in an attempt to mimic this characteristic uranium has been added to both artificial teeth and ceramic powders for the manufacturing of crowns and bridges. Moore and MacCulloch reveal that this was done as early as 1925 (2). According to the American Dental Association the use began before 1935 (3). In a patent by Lee and Müller in 1959 the inventors describe a mixture of cerium and uranium giving an improved shade of white (4). In recent years the question of radioactive ceramics has been addressed by Anusavice KJ (5): “The degradation of dental ceramics generally occurs because of mechanical forces or chemical attack. The possible physiological side-effects of ceramics are their tendency to abrade opposing dental structures, the emission of radiation from radioactive components,…”

At the end of the seventies and beginning of the eighties Prof. Eiko Sairenji et al at Nihon University placed the issue of radioactive dental ceramics firmly on the table with a number of articles (6, 7, 8, 9, 10, 11, 12). This was some fifty-five years after the use of uranium in dental ceramics began. A number of articles by other investigators have been published (13, 14, 15, 16, 17).

In Sweden Prof. Rune Sörenmark established a cooperation with Prof. Sairenji (6). In 1979 Prof. Sörenmark also contacted The National Board of Health and Welfare (SoS) and requested an immediate halt to all use of dental ceramics containing over 100 ppm of uranium (18). The case was handed over to The Swedish Radiation Protection Institute, SSI. Their policy is to remove all radioactive compounds from the market if the benefits are non-existing or could be achieved otherwise (19). Due to the lack of expertise in the area of dental materials SSI requested the view of SoS concerning the necessity to include uranium in dental porcelain. SoS never answered that request. The case was reported to The Parliamentary Ombudsmen, JO. Since the case was older than two years JO saw no possibility to act. They did however find that the case was closed by SoS in 1982 without ever answering the request from SSI (20).

The only radioactive compound regulated for use in dental material is – to my knowledge – uranium when used in dental porcelain and porcelain teeth in the USA. This standard is explicitly limited to defining maximum uranium content in prefabricated artificial teeth made from fused porcelain and porcelain powders for making custom crowns and bridges. The uranium content is rather low and must not exceed 0.03% (3).
In recent years it seems as though depleted uranium, a waste product from the manufacturing of nuclear weapons and fuel has been favored. Natural uranium has however also been used.

It has been argued that uranium mainly emits $\alpha$-radiation that can not penetrate the oral mucosa. There are however several occasions when for example crowns are grinded within the mouth of the patient. Unintentional injury of the oral mucosa is not uncommon. Imbedding of dental materials into the mucousa is well known.

For example Levison DA et al say (21):
“X-ray energy spectroscopy (XES) of all particulate matter found by light microscopy in histological sections of 222 oral lesions revealed a much wider range of elements than expected from dental amalgam. Subsequent XES of a variety of endodontic materials, impression materials and toothpastes indicated possible sources for virtually all elements identified in the histopathological lesions.”

“…possible implications of local implantation and large scale ingestion of such substances are discussed. “

Inhalation and swallowing of radioactive powder during dental treatment or teeth grinding is not unlikely.

**Radioactive compounds in some dental composites and other materials**

I would like to bring into the open the question if the use and concentration of radioactive compounds in dental materials has accelerated during later years. No scientific articles have been found dealing with this subject. However, several patents reveal the use of radioactive compounds in dental composites. One of the big changes that have taken place within dentistry in recent years is that of the introduction of dental composites. As being the main alternative to dental amalgam its use has risen greatly over the last decades.

Polymers used in dental composites are X-ray translucent. In composites X-ray opacity has been achieved by adding various heavy metal fillers, some being toxic, others being radioactive. Proposed fillers include uranium, thorium, lead, mercury, barium, bismuth etc. Fillers are also added to achieve wear-resistance, reduced shrinkage etc. The total amount of all sorts of fillers can be as high as 87% - the rest being polymer (1).

According to Cahn et al X-ray opacity is readily achieved by non-radioactive substitutes: “Radiopacity of composites, which is essential for restorations in posterior teeth, is readily achieved by incorporation of Ba, Sr, or Zn in the glass formulation.” (1)

Rheinberger V et al reveals in their patent that thorium is used as one such filler (22):
“Disclosed as X-ray opaque fillers in EP-PS 0 011 735 are solid, sparingly soluble heavy metal compounds, such as barium sulfate, barium fluoride and barium silicate, bismuth, zirconium, lanthanum and thorium compounds and compounds of the rare earth metals.”

“It is a disadvantage of these materials that the heavy metals frequently used are toxic and sometimes radioactive, whilst the oxides of the rare earths can lead to undesired discolorations of the filling or prosthesis.”

Masuhara E et al. Further establishes the use of radioactive fillers in dental composite (23):

“… dental filling material which has been ordinarily used in dental application. Examples of such a dental filling material are apatite, soda-lime glass, silica, quartz, silica gel, borosilicate glass, synthetic sapphire (alumina) and radioactive opaque filling materials, such as barium oxide and zirconium glass.” In this example it is more likely that the authors mean radioactive impurities rather than intentionally added isotopes of barium and zirconium.

Smid J et al says (24):

“It is therefore an object of this invention to provide means for imparting radiopaque characteristics to a wide range of polymers.

It is a further objective of this invention to provide radiopaque composites containing heavy metal atoms which are evenly distributed within a polymer.”

“Most preferred heavy metals include barium, bismuth, lead, mercury and uranium.”

In another patent Sid et al say (25):

“The most preferred bismuth, mercury and uranium salts are bismuth tribromide, bismuth nitrate and acetate; uranyl bromide, nitrate and acetate; mercury nitrate and acetate, and the like.”

In a third patent Smid et al say (26):

“Abstract

Novel radiopaque materials comprise heavy metal salts, such as bismuth and uranium salts complexed with a polymer. The metallic complexes which are permanent, nonleachable and have radiopacities at least equivalent to that of aluminum do not adversely affect the mechanical and physical properties of compositions. They are useful
as medical and dental resins, in fabricating medical and dental appliances, prosthetic devices, ..."

Temin SC of Colgate Palmolive Co holds a patent titled: Radio-opaque dental restorative composition using one or both of thorium and tantalum oxides as the only x-ray absorbent (27):

“The radiopaque dental filling compositions based on liquid polymerisable organic resin binders and finely divided inert inorganic radiopaque filler particles essentially contain as the only X-ray-absorbing component of the radiopaque filler particles 3 to 10 % by weight of the total filler particles of thorium dioxide or tantalum pentoxide or a mixture of thorium dioxide and tantalum pentoxide.”

A passage from the British patent GB695278:

“A dental cement contains uranium compounds, e.g. uranyl compounds and red coloring materials, e.g. gold oxide, chrome-alumina colours, copper aluminate and manganic oxide, which give the cement an appearance similar to natural teeth both in natural and artificial light.” (28)

Rawls HR et al say in their article (29):

“It was found that, when present in PMMA at 11 to 14%, several compounds of either bismuth or uranium or 35% of an organo-zirconium compound impart radiopacity equivalent to that of aluminum.”

Michl, et al. (30):

“European Pat. No. 11,735 describes dental filling materials containing as the contrast medium compounds of barium, bismuth, lanthanum, thorium and rare earth metals, preference being given to the use of barium sulphate. “

From Walkowiak, et al. (31)

“Abstract

The invention provides dental materials which are opaque to X-rays and are based on organic plastics in paste form, which comprises (a) a polymerizable binder, (b) a crosslinked bead polymer and (c) an X-ray contrast medium.”

“The materials are useful, inter alia, for filing dental cavities.”

“Barium compounds, for example barium sulphate, barium silicate and barium fluoride, are very particularly suitable. However, compounds of bismuth, for example bismuth
oxynitrate, zirconium, for example zirconium dioxide, and lanthanum, for example lanthanum oxide and compounds of thorium and the rare earth metals are also suitable.”

A translation of Botezatu E et al could perhaps be fruitful (32).

Thorotrast

The record of thorium in medicine is one of great sadness. A thorium based radiological contrast medium known as Thorotrast has previously been used in medicine. Its use has been abandoned because it induced cancer in a number of patients treated with the product. A great number of Thorotrast studies have been performed worldwide – over 1000 hits in Medline. Thorotrast is considered a dark story in medical history (33, 34, 35).

Ways of administration and dose from Thorotrast are not comparable to those of thorium in dental materials. It however shows that radioactive compounds should be treated with the greatest respect when used within the body.
References


17/ Gorban G. [Optical behavior, especially under ultraviolet rays, of certain dental porcelains]. [Article in French]. SSO Schweiz Monatsschr Zahnheilkd 1972;82(6):645-70


27/ Temin SC. Radio-opaque dental restorative composition using one or both of thorium and tantalum oxides as the only x-ray absorbent. Patentnumber CH646600. December 14 1984. COLGATE PALMOLIVE CO (US).

28/ Patentnummer: GB695278. EC klassifikation: A61K6/06 Ekvivalenter: CH281900


Other references of interest

