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URANIUM IN DENTAL PORCELAIN:

A Review of Current Literature

Yrd. Doç. Dr. Gözlem CEYLAN*
Prof. Dr. Hülya KÖPRÜLÜ***
Araş. Gör. Dt. Murat KURT****
Doç. Dr. Tarık BAŞOĞLU**
Yrd. Doç. Dr. Ahmet Umut GÜLER*
Yrd. Doç. Dr. Oktay YAPICI**

DENTAL PORSELENLERDE URANYUM :
Mevcut Literatürlerin Derlemesi

ÖZET

Dental seramikler doğal görünümleri, dayanıklı kimyasal yapıları ve optik özellikleri ile tanınır. Uranyumun floresan etkisinden dolayı, bazı yapay porselen tiplerinde bu gibi bileşikler aşırı miktarda kullanılmıştır. Derlememizde farklı ülkelerde üretilen porselen tozu ve suni porselen dişlerdeki uranyum içeriği ile ilgili literatür incelendi.

Anahtar kelimeler: Dental seramikler,Uranyum.

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ABSTRACT

Dental ceramics are known for their natural appearance and their durable chemical and optical properties. The flourescent effect of Uranium, present in some artificial porcelain, had resulted in extensive use of such compounds during a certain period. The objective of this article was to review the spesific literature concerning the content of uranium in porcelain powders and porcelain denture teeth marketed in different countries.

Keywords: Dental ceramics,Uranium.

INTRODUCTION

Most cultures through the centuries have acknowledged teeth as an integral facial structure for health, youth, beauty and dignity.[1] Missing anterior teeth create physical, functional and esthetic problems as well as psychological and social disturbances. According to teeth loss, even if functional problems occur, aesthetic has got importance. Dental ceramics have different application areas and types due to reflecting naturalness for natural teeth colour, and are widely used nowadays.[2,3]

Dental ceramics are known for their natural appearance and their durable chemical and optical properties. Although routine use of ceramics in restorative dentistry is a recent phenomenon, the desire for a durable and esthetic material is ancient.

In 1942, it was discovered that uranium compounds present in dental porcelain cause artificial porcelain teeth to fluoresce. This resulted in extensive exploitation of such compounds.[4]

*Ondokuz Mayıs Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi Anabilim Dalı Öğretim Üyesi
**Ondokuz Mayıs Üniversitesi Tıp Fakültesi Nükleer Tıp Anabilim Dalı Öğretim Üyesi
***Ondokuz Mayıs Üniversitesi Diş Hekimliği Fakültesi Diş Hastalıkları ve Tedavisi Anabilim Dalı Öğretim Üyesi
****Ondokuz Mayıs Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi Anabilim Dalı Araştırma Görevlisi

It has been found that the average uranium content in teeth,bone and soft tissue was 6.7, 8.4 and 64 ppb ash, respectively.[5] It has been reported that about 0.1 ppm of uranium is contained in a single tooth made of Japanese porcelain materials, even when no uranium compound has been intentionally added.[6,7]

There are no as yet recognized health risks to patients from the use of ceramics in prosthodontic and restorative dentistry, other than possible abrasive damage to opposing dentition and the potential for fracture.[8-10] However, an eventual radioactivity hazard due to uranium containing porcelain was never clinically investigated.

URANIUM

Uranium is a heavy, silver-white, lustrous, dense and slightly paramagnetic metal. Natural uranium is a commonly occurring weakly radioactive element. It is slightly softer than steel and reacts with cold water when present in a finely divided state. In air it easily oxidizes and becomes coated with a layer of oxide. Thus in nature uranium mainly occurs in oxidized form. Uranium is about as abundant as molybdenum and arsenic and more plentyful than mercury, antimony, tungsten and cadmium. It occurs in numerous minerals and is also found in lignite, monazite sands, phosphate rock and phosphate fertilizers. It is ubiquitous throughout the natural environment, being found in varying but small amounts in rocks, soils, water, air, plants, animals and in all human beings. In addition ,uranium is categorized as a heavy metal with a chemoxic potential.[11,12]

The daily intake of uranium is estimated to be 1-2 µg in food and 1.5 µg in water consumed.[13] The human body contains approximately 56 µg of uranium of which 32 µg (56%) is in the skeleton , 11 µg is in the muscle tissue, 9 µg is in fat , 2 µg is in blood and less than 1µ is in lungs, liver and kidneys.[14,15] The uranium in the human body is derived mostly from uranium in food, especially from vegetables, cereals, and table salt.[15,16]

All isotopes of uranium are radioactive. Naturally occurring uranium has three isotopes, namely 238U, 235 U, and 234U.

The penetration range of a typical 5MeV alpha particle is approximately 4 cm in air and only about 50µ in soft tissue. Therefore they are unable to penetrate even the superficial keratin layer of human skin. As a result, uranium principally represents only an internal radiation hazard.

USE OF DEPLETED URANIUM

One intended use of Depleted uranium (DU) was a cladding material in fast-breeder reactors, and was also used as a fluorescent additive in dental porcelain crowns (now discontinued), as X-ray radiation shielding in hospitals, as counterweights for rudders and flaps in commercial aircraft and fork lifts, and in the keels of sailing yachts. DU was ultimately selected due to its availability, price and pyrophoricity.[11-19]

URANIUM IN DENTAL PORCELAIN

The toxicity of leachable elements in dental ceramics are all extremely low.[8] All minerals, from which dental porcelains derive, emit extremely low levels of radiation.[8-10] Under voluntary regulatory guidelines established in 1981, radiation levels in dental porcelains should not have been increased by the manufacturer beyond their natural background levels and new International Standarts Organization (ISO) specification call for complete monitoring of radiation levels in ceramics for all ceramic prostheses.

In 1959 an improvement was made of the white fluorescence by combining cerium and uranium compounds. By analyzing the composition of different dental porcelains with the X-ray fluorescence method, Nally, Meyer and Niederer[20] found all the porcelain powders analyzed to have high contents of uranium, 0.02-1.97 per cent. The beta-activity was measured with a G-M counter and the maximum dose equivalent rate calculated for 1 g of porcelain was found to be 3.81rem year.[4]

In another study the uranium content of porcelain teeth and powders, used in the United States, was found to be higher than 500 ppm, using a NaI(Tl) detector.[21] The concentration of uranium in porcelain teeth marketed in Japan was studied by Sairenji et al.[7] using a fission track method. It was reported that, the uranium content in dental porcelain powders varied from a few ppm to 1090ppm.[22] High contents of uranium (345-1090ppm) were detected in the powders of ëenamelí, ëdentiní, ëeffectí, ëcolorí and ëgumí which were used for the superficial parts of a porcelain crown, while low contents of uranium (1.6-2.7ppm) were found in the ëopaqueí and ëtranslucentí samples. Recently the amount of uranium was analyzed by means of neutron activation analysis.23 Of the three brands made in the U.S.A., the uranium content of the Ceramco porcelain powder was fairly consistent from powder to powder, averaging 80.7 ± 15.1 ppm, while the Jelenko samples (except No. 62) were 3-7 times that of the Ceramco brands. The uranium content in Vita VMK 68 varied between 384-682ppm. In VitaDur, this variation was between 711 and 1016ppm.[4]

Landa and Councell[24] performed leaching studies on the release of uranium from 33 glass items and two ceramic items in which uranium had been used as a coloring agent.

According to OíRiordan & Hunt[25] the irradiation dose to the mucosa of the upper lip may exceed the limit recommended by the International Commission on Radiological Protection (ICRP) for the average dose to the general organs or tissues of members of the public. They found a concentration of uranium in porcelain powders of 410 parts per million by weight on an average and two of the seventeen powders examined had about 1000ppm. The concentrations of uranium in denture porcelain teeth were found to be similar. A calibrated fluorometer and a shielded end-window G-M counter were used for analyzing the amount of uranium present in the samples.

Sairenji et al.[4] found that Shofu Ace teeth contained 3.6ppm, Shofu real 18ppm, G-C Livdent 9.4ppm and Trubyte Bioblend 82ppm. The dose equivalent to oral mucosa was calculated assuming that compounds of uranium used were natural and that the teeth were in contact with oral tissues. The dose equivalent expressed in rem was computed by modifying the values of the absorbed dose with the Quality Factors recommended in the ICRP publication 26, i.e. 20 for alpha particles and one for beta particles.[23]

It is difficult, however, to estimate the actual risk and biological effects resulting from the use of porcelain teeth containing uranium because there are some uncertain factors which may affect the radiation dose. The dose rate due to alpha particles decreases steeply as the penetration depth increases. The depth of the basal cell layer is, therefore, important for the evaluation of radiation effects on living tissues. The epidermal thicknesses were found to be 10-470 µm in lips (mean: 178µm), 10-460µm in tongue (mean: 101µm) and 23-140µm in gingival tissue (mean: 56µm). Therefore, the basal cells may possibly be irradiated when the epidermis is only 10µm thick. On the other hand, there are some factors which may have the ability to reduce the radiation exposure of the oral mucosa. These factors are the layers of saliva and dental pellicle and plaque deposited on the surface of teeth that provide radiation shielding. There has not yet been adequate information as to the actual thicknesses of the salivary and other layers. One study suggests the value of 120-220 µm for the salivary layer[21]. With such layers the alpha particles can be completely cut off, and the absorbed dose of oral mucosa would then be principally due to beta particles.[4]

CONCLUSION

It is difficult to estimate the actual risk and biological effects resulting from the use of porcelain containing uranium because there are some factors which may effect the radiation dose. Factors such as the layers of saliva and dental pellicle and plaque deposited on the surface of teeth provide radiation shielding.

No prospective human trials involving the long-term effects of uranium containing porcelain powders could be found in the literature. A large-scale survey of dental patients, particularly regarding oro-pharingeal malignancy could be very informative.

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Yazışma adresi:

Yrd. Doç. Dr. Gözlem CEYLAN

O.M.Ü. Diş Hekimliği Fakültesi
Protetik Diş Tedavisi Anabilim Dalı
Kurupelit/SAMSUN
Fax: 0 362 4576032
Tel: 0 362 4576000/3008
E-mail: gceylan@omu.edu.tr.