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Technical Information Bulletin

Radioactivity of Z5 Implants

Natural radiation exposure

Inhalation and ingestion of natural radionuclides (assuming western lifestyle and dietary habits) add up on average to an annual effective dose* (He) of about 1.4 mSv. In addition, we are exposed to an annual external radiation of 0.7 mSv, resulting from a cosmic component with 0.3 mSv and a terrestrial component of 0.4 mSv. Overall, this results e.g. in Germany, to an average annual effective dose of 2.1 mSv. Given the variability of the individual components, particularly the exposure to Rn-222, the annual effective dose for the average person in Germany will be in the range of 2 to 3 mSv.

In the UNSCEAR 2000 Report a value of 2.4 mSv / year effective dose is given for average conditions in the northern hemisphere [1]

Zirconia ZrO2-TZP radiation dose

Study Porstendörfer et al. – Radiation risk estimation based on activity measurements of zirconium oxide implants [2]

Ouestion
Measuring the specific radioactivity of orthopedic implants (hip joint ball heads) made from zirconia compared to metallic hip joint implants and ball heads made from Al2O3.

Method
Biological effectiveness of a-radiation (compared to ß- or -y-radiation) is about 20 times higher. Therefore a-radiation was measured with the help of y-spectral analysis determining radionuclides and their mass fractions.

Result
ZrO2 samples (hip joint ball heads mass-/weight about 100 grams) release on average an effective dose rate (He*) between 0.13 mSv / year and 0.53 mSv / year (see Table 1) and are thus lower than the limit of 1 mSv / year recommended by ICPR (International Commission on Radiological Protection).

* Effective dose (He): The effective dose (unit: Sievert [Sv]) is an indicator of whole-body dose, measuring the total stochastic risk of radiation re. cancer and leukemia of a person exposed to ionizing radiation.

The mass (weight) of dental implants is about 1 to 2 grams, this results in a correspondingly low radiation activity with an effective dose rate (He) of only about
1 % of the limit recommended by the ICRP. The radiation exposure from a Z5 implant is thus about 100 times lower than the limit.

Table I

Specific Activities of Key Nuclides of ZrO2 and Al2O3 Raw Material (Powder)

Table 1 (from Porstendörfer [2]): Comparison of the radioactivity of 5 ZrO2 samples with Al2O3, sample size per 100 g.

Sample (Raw Material)	Uranium-Radium (Bq/kg) ^{238}U	^{226}Ra	^{210}Pb	Thorium (Bq/kg) ^{232}Th	Φ (cm^2/day)	H_m (mSv/year)	H_e (mSv/year)	C_m (Bq/kg)	C_g (Bq/kg)
ZP (ZrO_2)	6.2 ± 2.0	0.5 ± 0.2	<13	0.4 ± 0.1	1.7 ± 2.0	2.6	0.13	1.6–2.5	16.2
ZP (ZrO_2)	4.0 ± 2.0	2.1 ± 0.2	17.5 ± 13.0	2.3 ± 0.1	4.7 ± 2.4	7.2	0.36	3.7	10.3
ZP (ZrO_2)	5.1 ± 3.2	1.7 ± 0.2	66.4 ± 8.0	2.4 ± 0.1	7.0 ± 1.0	10.6	0.53	7.3	13.8
ZP (ZrO_2)	3.6 ± 1.6	1.6 ± 0.2	70.4 ± 7.9	2.1 ± 0.1	6.1 ± 1.1	10.4	0.52	7.1	13.7
ZP (ZrO_2)	6.0 ± 3.2	1.4 ± 0.2	69.0 ± 7.9	2.2 ± 0.1	6.6 ± 1.0	10.0	0.50	7.6	15.2
AP (Al_2O_3)	3.0 ± 0.7	<0.2	<2.0	0.2 ± 0.1	2.1 ± 2.1	3.2	0.16	0.7–0.9	5.0

Φ_α, Alpha particle flux density from the surface of the sintered material; H_m, equivalent dose of the tissue surrounding the implant; H_e, effective dose; C_m, weighted specific activity; and C_g, the weighted specific activity limit derived from the measured data (statistical error with 2 standard deviation confidence).

Literature

[1]United Nations: Sources, Effects and Risks of Ionizing Radiation. UNSCEAR 1982, 1988, 1993, 2000 Report to the General Assembly, with Scientifi c Annexes. New York 1982, 1988, 1993, 2000.

[2]Porstendörfer, J. et al.: Radiation risk estimation based on activity measurements of zirconium oxide implants, Journal of Biomedical Materials Research, Vol. 32, 663-667 (1996)