

numbers; these causes include multiple myeloma and breast cancer. Leukemias have been expected by many to be elevated in this population, but they are not. Life shortening is not a cause of death, but it is included because the lack of life shortening came as a surprise to many.

Bone Sarcomas

A total of 85 subjects with diagnosed bone sarcomas are known or suspected to have had radium deposited within their bodies in the form of ^{226}Ra or ^{228}Ra or both. Five individuals with a diagnosed bone sarcoma also had a diagnosed head carcinoma. These 85 subjects represent about 1.3% of the total exposed population. For the smaller population with measured radium burdens, 64 of a total of 2,383, or 2.7%, developed bone sarcomas. As will be discussed in a later section, the incidence of bone sarcoma increases rapidly with increasing radium intake.

As a producer of bone sarcomas, ^{228}Ra has been found to be more effective than ^{226}Ra . Rowland et al. (1978) found an effectiveness ratio (^{228}Ra to ^{226}Ra) of 1.5 when average skeletal doses were used and 2.5 when initial systemic intake was used as the measure of risk. When the measured radium cases are arranged in order of increasing initial systemic intake, expressed as μCi of ^{226}Ra plus 2.5 times μCi of ^{228}Ra , the lowest-dose case with a bone sarcoma is number 2,102 on the list of 2,383 cases. That is, no bone sarcomas occurred in the 2,101 cases with lower combined intakes than this case. The value of the combined systemic intake for this case was 100 μCi , from 81.53 μCi of ^{226}Ra and 7.42 μCi of ^{228}Ra . This lowest-dose sarcoma case was a female dial painter who started work in 1918 and died in 1983 of a bone sarcoma diagnosed in 1981. The distribution of the bone sarcoma cases by sex is summarized in Table 7. Table 8 compares the distribution of bone sarcomas for dial workers and all other radium subjects.

An examination of the appearance of the bone sarcomas with the passage of time after first exposure to radium is of interest. The first bone sarcoma was observed 5 years after first exposure to radium. The bone sarcomas seemed to appear quickly after a 5-year latent period. After about 50 years the frequency fell markedly. However, the diagnosis of a bone sarcoma 63 years after first exposure to radium is evidence that this malignancy can appear at any time in life, given a sufficiently large initial systemic intake of radium. The subject with this latest appearance time had a combined intake of 100 μCi , the lowest intake associated with this malignancy. Figure 10 shows the number of bone sarcomas diagnosed in each 5-year period after exposure.