

Pathologic fracture is another form of injury which results from the bone destruction produced by bone-fixed radioactive materials.

Not surprisingly, Evans (1966), in his study of the radium cases at MIT, and subsequently Finkel et al. (1969), in their study at Argonne, developed a quantitative measure of the radium changes visible in radiographs, which they called the *X-ray score*. This scoring system was described (Evans 1966) as follows:

In order to quantify the effect on the bones, Dr. John E. Gary, in collaboration with Dr. Robert J. Hasterlik of the Argonne Cancer Research Hospital and Dr. Asher J. Finkel of the Argonne National Laboratory developed a reproducible X-ray scoring system several years ago. The body is divided into 20 radiographic areas, and 34 films covering these areas and including both lateral and antero-posterior views of several areas are obtained.

In his publication, Evans (1966) plotted the X-ray score against various measures of skeletal dose to demonstrate how the scores were essentially zero ("no symptoms") until the dose level was reached at which spontaneous fractures and malignancies were first seen. The cases in this particular study included ". . . about 270 individuals for whom complete, whole-body X-ray scores have been obtained." In 26 of these individuals, 29 bone sarcomas had occurred, and some 20 subjects had suffered 53 spontaneous bone fractures.

Evans (1966) felt that the primary cause of osteomyelitis and dense-bone necrosis was injury to the circulation in bone. He stated that

the primary deposit of radium or mesothorium in the bone serves to irradiate the cells of the circulatory system in bone and thus to destroy a portion of the circulation. Such a situation would then be followed by necrosis of the areas thus deprived of their circulation.

Rowland et al. (1959b) showed, by using microradiographs of thin sections of undecalcified bone, that bone from high-level radium cases was characterized by mineral plugs in the vascular spaces of Haversian systems. These plugs, which obliterated the small blood vessels in these systems, increased in number with increasing radium body content. Since bone from individuals exposed to very high levels of radium often had up to 25% of the Haversian canals plugged, a marked disruption of blood flow through such