

## X-rays: A Boon to Radiology; a Hazard to Human Health

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### Case Study

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### ABSTRACT

Since the evolution of mankind, human beings have been busy in inventing and discovering new things. From the discovery of fire to the discovery of electrons to the invention of the computer to the invention of bionic devices, an era has passed in the development and advancement of technology in every field whether it is science, medicine, or any other technology. Moreover, man has an enormous curiosity about the discovery of nature since its evolution. Science and the medical field have seen several changes in their field since the evolution of nature. Every invention and discovery has its benefits and hazards whether it is related to nature or is manmade. This article reviews the benefits and hazards of a discovery that changed the era of medical and dental science and technology, the "X-rays". X-rays are forms of electromagnetic radiation that are used in diagnostic radiology however they also cause several hazards to the human body like mutations, and physical deformities, prove harmful to foetus, and even cause cancer.

**Keywords:** Health, Radiation, Protection, X-rays.

### Introduction

William Conrad Roentgen, a German physicist, discovered X-rays on November 8, 1895. By December 28, he had thoroughly investigated the

properties of X-rays and prepared a manuscript regarding his experiments. In recognition of his outstanding contribution to science, he was awarded the first Nobel Prize in 1901.<sup>1</sup>

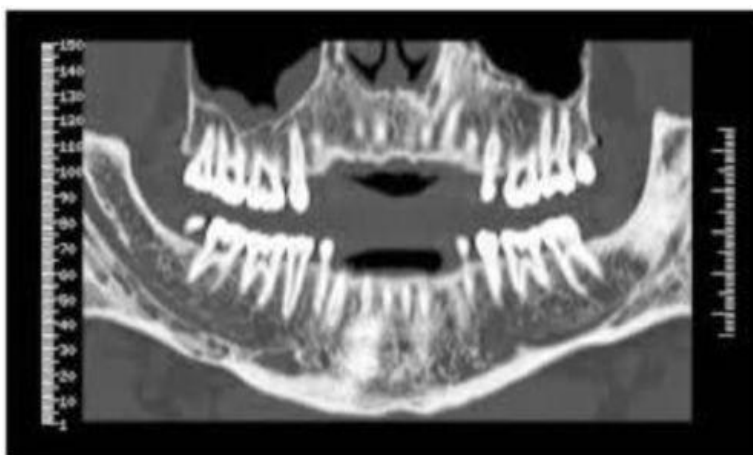


One of the first X-ray photographs, taken by the German physicist Wilhelm Conrad Roentgen, showing his wife's hand.

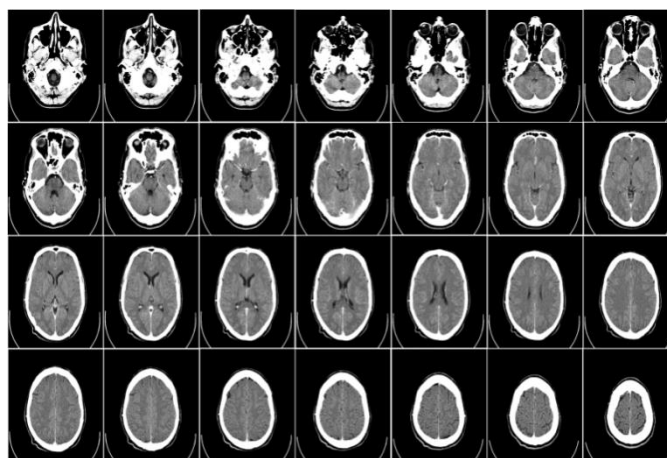
### Uses of X-Rays in medical science

X-rays are used in medicine for medical analysis. Dentists use them to find complications, cavities, and impacted teeth. A mammogram (also called a mammography exam) is a safe, low-dose x-ray of the breasts. A high-quality mammogram is the most effective tool for detecting breast cancer early. Roentgen's remarkable discovery was one of the most important medical advancements in human history. X-ray technology lets doctors see straight through human tissue to examine broken bones, cavities, and swallowed objects with extraordinary ease. Modified X-ray procedures can

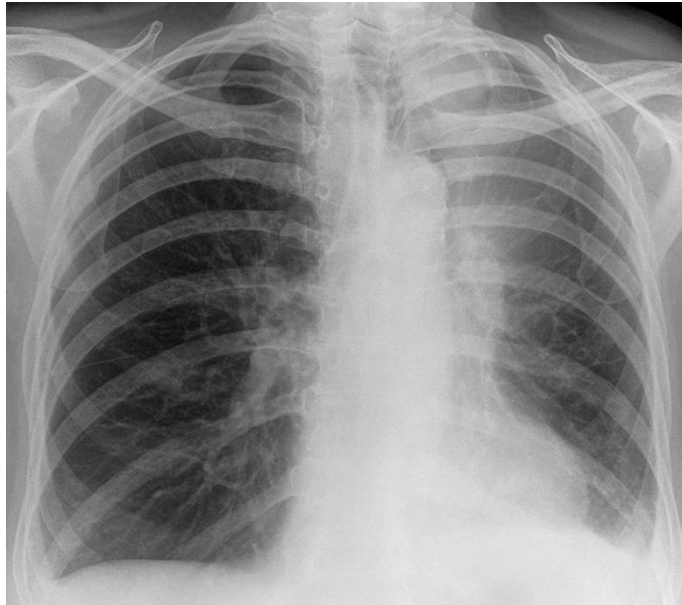
be used to examine softer tissue, such as the lungs, blood vessels, or the intestines.<sup>2</sup> Computed tomography (CT), Fluoroscopy, and radiography (conventional X-ray) including mammography all use ionizing radiation to generate images of the body. CT scan, radiography, and mammography work on the same basic principle: an X-ray beam is passed through the body where a portion of X-rays are absorbed or scattered by the internal structures, and the remaining X-ray pattern is transmitted to a detector (a film or a computer screen) for recording or further processing by a computer.<sup>3</sup>



**A Panoramic radiograph (OPG)**



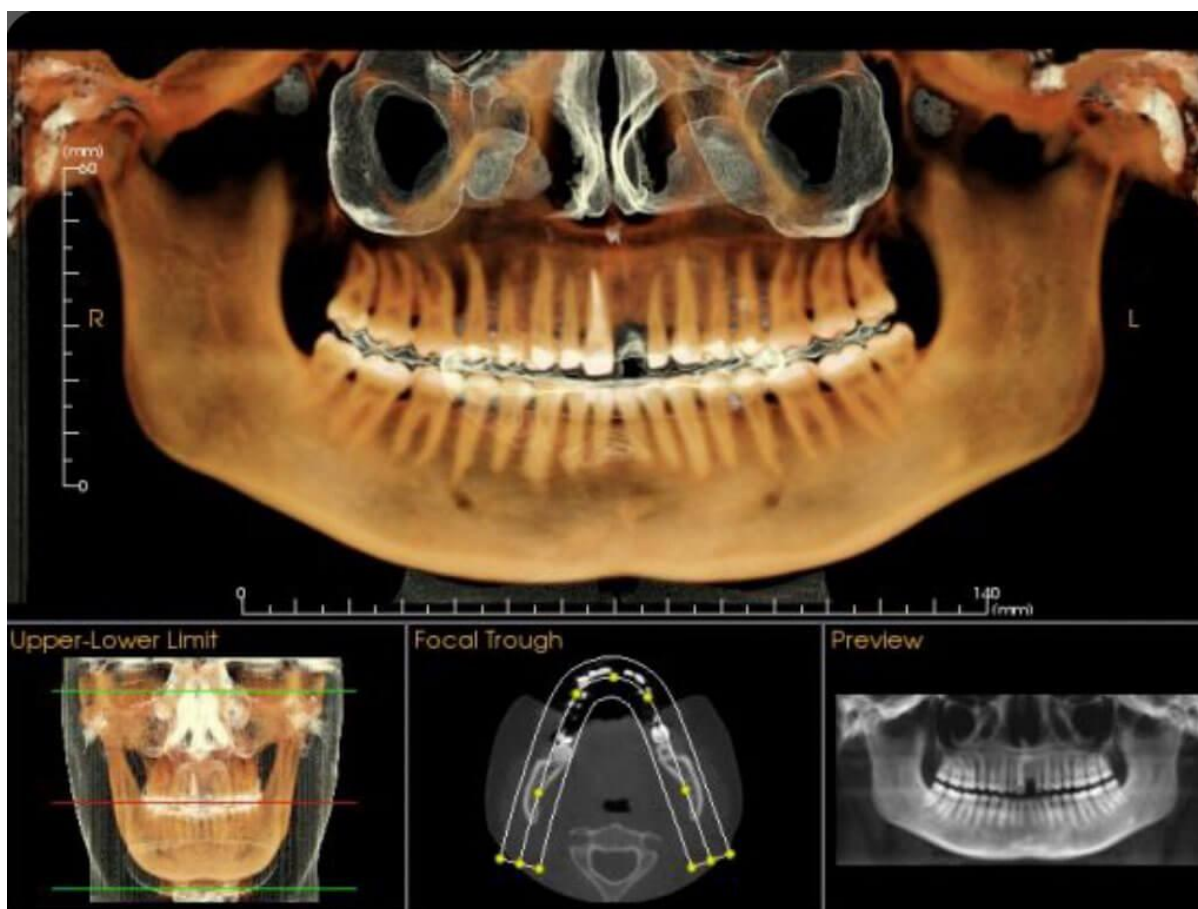
**Computed Tomographic scan (CT scan) of the brain**



**Normal Chest radiograph**



**Posterior anterior radiograph of the skull**



**Cone beam computed tomography (CBCT) scan**

#### **Hazards of X-rays – Historical view**

The discovery of X-rays brought a dynamic change in the medical field and diagnostic radiology. X-rays are a form of electromagnetic radiation similar to radio waves, microwaves, visible light, and gamma rays. X-ray photons are highly energetic and have enough energy to break molecules and hence damage living cells.<sup>4</sup>

Many somatic changes of radiation became evident a few months after X rays were discovered. Roentgen announced his discovery in December 1895. In 1896, 23 cases of radio dermatitis were reported in the world literature.<sup>5</sup>

Between 1911 and 1914, three review articles identified 54 cancer deaths and 198 cases of radiation induced malignancy. The first American

fatality occurred in 1904 when Thomas Edison's assistant, Clarence M. Dally, died of cancer. A few farsighted individuals cried out for radiation controls, but their pleas were largely ignored. Clastrophes continued until the whole medical community got alarmed. Finally in 1921, the first official action was taken when the British X-ray and Radiation Protection committee was founded to investigate methods for reducing exposures. But, due to lack of satisfactory unit of radiation measurement, their efforts were severely hampered.<sup>6</sup>

#### **Radiation Hazards – Effects on human body**

In the human body, ionisation can directly cause damage to atoms in DNA, or indirectly by creating "free radicals" that can then damage DNA. Free radicals are highly reactive diffusible ions or

molecules with unpaired electrons that interact with cellular components, and over 70% of cellular damage is caused by free radicals.<sup>7</sup> Ionisation results in the development of biological and physiological alterations in the molecular structures within a cell such as inability of the cell to divide correctly that may manifest themselves

seconds or decades later. Consider ultraviolet radiation. It is well known to cause sunburn not long after exposure to the sun, and prolonged exposure increases the lifetime risks of developing melanoma (skin cancer) many years after the exposure. UV radiation is a form of natural radiation.<sup>8</sup>

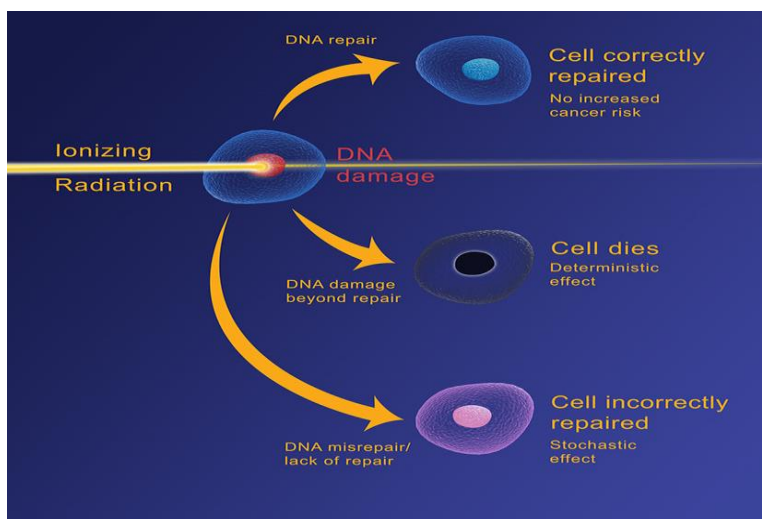


High-energy radiations such as ultraviolet radiation, X-rays, and gamma rays are ionising radiation since they can cause ionisation of atoms in the human body. Low-energy radiation such as visible light and radio waves do not cause ionisation of atoms and are forms of nonionizing radiation.<sup>9</sup>

#### **Radiation effects on DNA**

If radiation interacts with the atoms of the DNA molecule, or some other cellular component critical to the survival of the cell, it is referred to as a direct effect. Such an interaction may affect the ability of the cell to reproduce and, thus, survive. If enough atoms are affected such that the chromosomes do not replicate properly, or if there is significant alteration in the information carried by the DNA molecule, then the cell may be destroyed by “direct” interference with its life-

sustaining system. If a cell is exposed to radiation, the probability of the radiation interacting with the DNA molecule is very small since these critical components make up such a small part of the cell. However, each cell, just as is the case for the human body, is mostly water. Therefore, there is a much higher probability of radiation interacting with the water that makes up most of the cell’s volume. When radiation interacts with water, it may break the bonds that hold the water molecule together, producing fragments such as hydrogen (H) and hydroxyls (OH). These fragments may recombine or may interact with other fragments or ions to form compounds, such as water, which would not harm the cell. However, they could combine to form toxic substances, such as hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), which can contribute to the destruction of the cell. This is radiolytic decomposition of cell.<sup>10</sup>



This image shows what may occur after ionizing radiation causes DNA damage. The DNA can either repair correctly, DNA damage can be beyond repair and result in cell death (deterministic effect), or DNA can repair itself incorrectly (stochastic effect).

### Radiation Mucositis

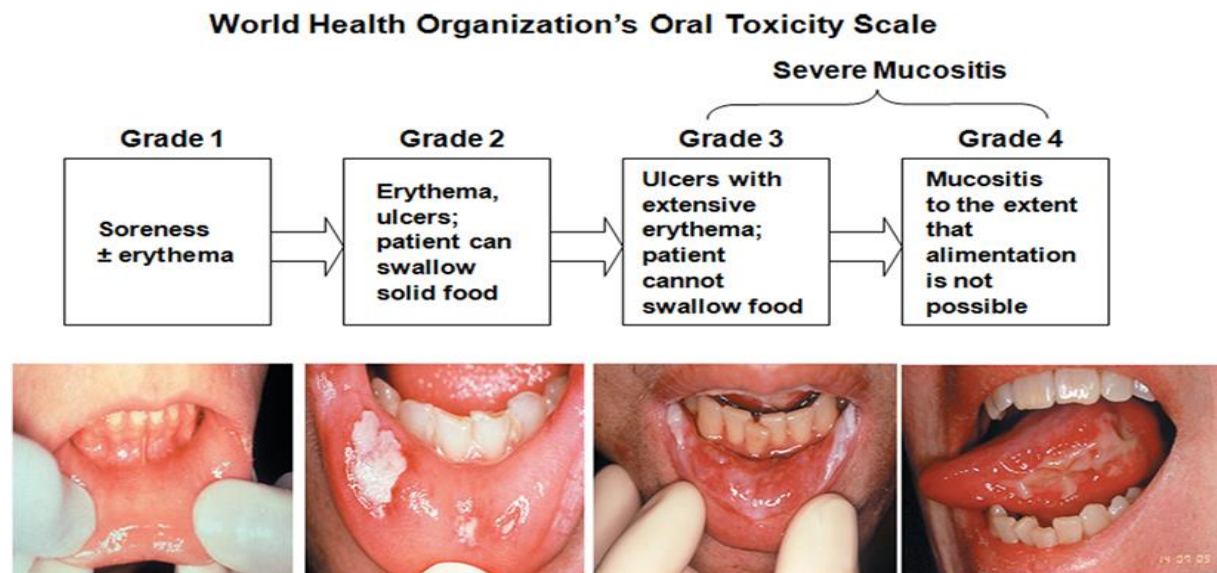
Oral mucositis (OM) is a major limiting acute side effect of radiotherapy for head and neck cancer. OM may also occur with chemotherapeutic agents like 5-fluorouracil (5FU) and methotrexate. The incidence of mucositis increases many folds with the use of concurrent chemotherapy. The spectrum of problems associated with mucositis includes oral pain, odynophagia, reduced oral intake, and secondary infections. Development of significant mucositis leads to unwanted interruptions in

radiotherapy especially after the 5th week of initiation leading to accelerated repopulation of resistant clones and compromised disease control. Mucositis develop due to effect of radiation and chemotherapy on rapidly dividing cells in the mucosa of the gastro intestinal mucosa.

Radiotherapy being a local treatment leads to mucositis in the irradiated area while chemotherapy adds to the local mucositis as well as entire mucosa of the body.<sup>11</sup>



Radiation induced mucositis of hard palate.



#### Grading of Radiation Induced Mucositis.

#### Acute radiation syndrome (ARS)

A very high radiation exposure delivered over a short period of time can cause symptoms such as nausea, vomiting within hours and can sometimes result in death over the following few days. This is known as acute radiation syndrome (ARS), commonly known as radiation sickness. It takes high radiation exposure to cause ARS, more than 40 gray (75rads) in a short lifespan. ARS is rare and comes from events like nuclear explosion or from a highly radioactive source. Exposure to low level of radiation does not cause immediate effects but can cause small increase in risk of cancer over a lifetime. Radiation exposure increases chance of getting cancer and the risk increases as the dose increases; higher the dose, greater the risk.<sup>12</sup>

#### Osteoradionecrosis (ORN)

High dose of radiotherapy often has serious effects on soft and hard tissues adjacent to neoplasm. Mucositis, atrophic mucosa, xerostomia and radiation caries are common. Because of its mineral composition, bone absorbs more energy than soft tissue and is more susceptible to secondary radiation. This leads to a complication termed as osteoradionecrosis (ORN). ORN is

defined as exposed irradiated bone tissue that fails to heal over a period of three months without a residual or recurrent tumour.<sup>13</sup> Osteoradionecrosis clinically includes pain, swelling, non-resolving painful mucosal ulcer with evidence of exposed bone or sequestrum, trismus, malocclusion, telangiectasia formation, exposed bone in the form of oral cutaneous fistula formation, pathologic fracture in severe cases.<sup>14</sup> Pain and evidence of exposed bone are the chief clinical features of ORN. Initially, the patient may have trismus, fetid breath, and an elevated temperature, although acute infection usually is not present. Exposed bone with a grey to yellow colour is seen in association with intraoral and extraoral fistulae. Pathological fractures may be present in severe cases. The exposed bone often has a rough surface texture that abrades adjacent soft tissue and causes further discomfort. The tissues surrounding the exposed bone may be indurated or ulcerated from infection or recurrent tumour. On physical examination, missing hair follicles, surface texture changes and colour changes are common findings that assist clinicians in assessment of the area of radiation injury.<sup>15</sup>

**Osteoradionecrosis (A) Extraoral****Radiation hazard in dental radiography**

The principal biologic risk from dental radiography is radiation induced cancer. Cancer induction probably has no threshold dose. Even a small dose of radiation may increase the patient's statistical probability of cancer development. The exposure of foetus from dental radiography during pregnancy would be similar in magnitude of reproductive organs. Previous studies suggest that the production of congenital defects from doses below 100 mSv is very small when compared with the normal risk for congenital defects (4.6%) and is negligible at 50 mSv or less. (NCRP report 54, 1977). It is prudent to use lead aprons on all female patients during first trimester of pregnancy.<sup>16</sup>

**Discussion**

The discovery of X-rays had brought dynamic changes in the field of science and medical radiology. X-rays are used in various diagnostic investigations like computed tomography, fluoroscopy, cone beam computed tomography, dental radiology and in other advanced imaging investigations. They are used to visualize radiological anatomy of human body, to investigate pathology in relation to diseases and infections and to visualize their effects on human body. Moreover, they are use in medical and dental radiology to visualise bone and internal structures

**(B) Intraoral**

like soft and hard tissues in case of traumatic injury. In fact, X-rays are used in every field of radiological science. X-rays are a form of ionizing radiation; they are harmful to human body and are hazardous to human health. They have various side effects on human body like radiation sickness, radiation cancer, and osteoradionecrosis and also can cause death in later stages if given in large doses. Radiation also causes mutations and can damage DNA, which can affect an individual or a population causing mutations for several generations. Radiation is harmful for foetus and cause mutations and congenital damage if given in large doses. X-rays are a boon to radiological science and are used in every field of radiology for diagnostic imaging but also prove hazardous to the human health. Every person working in radiological department or related to nuclear field should take precautions to protect him from radiation to avoid complications of radiations early or in later stages.

**Conclusion**

The main aim of the article is to emphasise the advantages of x rays, and also put a light on hazards of radiation and its effects on human health. As, radiation is harmful whether it is in large or small dose, it proves hazardous to human health and causes several complication in early or later stages. It is better and mandatory to take

precautions and safety measures to protect from radiation as the 'health is wealth'.

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