ISSN: 2157-2518
Journal of Carcinogenesis & Mutagenesis

OPEN ACCESS Freely available online

Commentary

Chromosomal Aberrations and Genomic Instability in Radiation Associated Cancers

Chahat Nidhar*

Department of Medical Quality Control, Chengdu Second People's Hospital, Chengdu, Sichuan, China

DESCRIPTION

Chromosomal aberrations are a defining feature of radiation-induced genetic instability and play a central role in the initiation and progression of cancer. Exposure to ionizing radiation results in a wide spectrum of chromosomal alterations that disrupt normal cellular processes and contribute to tumorigenesis. These aberrations primarily arise from the misrepair of DNA double-strand breaks, which are among the most severe and biologically significant forms of radiation-induced damage. The inability of the cell to accurately repair such lesions leads to permanent structural and numerical changes in chromosomes, thereby compromising genomic integrity.

Structural chromosomal aberrations include deletions, duplications, inversions, and translocations. Deletions result in the loss of genetic material, which may involve critical tumor suppressor genes, thereby removing essential regulatory controls on cell growth. Duplications, on the other hand, can lead to gene amplification, increasing the expression of oncogenes and promoting uncontrolled proliferation. Inversions alter the orientation of chromosomal segments, potentially disrupting gene function, while translocations involve the exchange of genetic material between non-homologous chromosomes. These translocations can generate fusion genes that encode abnormal proteins with oncogenic properties, a phenomenon frequently observed in radiation-associated malignancies.

In addition to structural changes, radiation exposure can also induce numerical chromosomal aberrations such as aneuploidy, where there is a gain or loss of entire chromosomes. This condition arises due to defects in chromosome segregation during mitosis, often caused by radiation-induced damage to the mitotic spindle apparatus. Aneuploidy leads to an imbalance in gene expression and is a hallmark of many cancers, contributing to tumor heterogeneity and progression. The combined presence of structural and numerical aberrations creates a highly unstable genome that facilitates the accumulation of additional mutations. One of the most critical aspects of radiation-induced chromosomal instability is its persistence over time. Even after the initial exposure, affected cells may continue to exhibit elevated rates of chromosomal abnormalities across multiple generations. This phenomenon, known as genomic instability, reflects an ongoing inability of the cell to maintain chromosomal integrity. It is associated with defects in DNA repair pathways, cell cycle checkpoints, and mitotic regulation, all of which contribute to the continuous generation of genetic alterations.

The frequency and complexity of chromosomal aberrations are influenced by several factors, including the type and dose of radiation, duration of exposure, and the biological characteristics of the affected cells. High doses of radiation are more likely to produce complex aberrations involving multiple chromosomes, whereas lower doses may result in simpler, yet still significant, alterations. Understanding these dose-dependent effects is essential for evaluating cancer risk and establishing safety standards in medical, occupational, and environmental settings.

Chromosomal aberrations are not merely passive indicators of radiation exposure but active contributors to carcinogenesis. They can disrupt key regulatory pathways by activating oncogenes, inactivating tumor suppressor genes, and altering gene expression patterns. This disruption leads to uncontrolled cell division, resistance to apoptosis, and increased potential for invasion and metastasis. As such, chromosomal instability serves as both a marker and a driving force in cancer development.

In conclusion, chromosomal aberrations represent a critical link between radiation exposure and genetic instability in cancer. Their formation, persistence, and biological consequences underscore their importance in understanding the molecular basis of carcinogenesis. Continued research in this area is essential for improving diagnostic tools, refining therapeutic strategies, and developing effective measures to prevent radiation-induced cancers.

Correspondence to: Chahat Nidhar, Department of Medical Quality Control, Chengdu Second People's Hospital, Chengdu, Sichuan, China, E-mail: chahat@nidhar.cn

Received: 31-Dec-2025, Manuscript No. JCM-26-31156; **Editor Assigned:** 02-Jan-2026, Pre QC No. JCM-26-31156 (PQ); **Reviewed:** 16-Jan-2026, QC No. JCM-26-31156; **Revised:** 23-Jan-2026, Manuscript No. JCM-26-31156 (R); **Published:** 30-Jan-2026, DOI: 10.35248/2157-2518.26.17.003

Citation: Nidhar C (2026). Chromosomal Aberrations and Genomic Instability in Radiation Associated Cancers. J Carcinog Mutagen. S57:003