ABSTRACT:

In the era of modern medicine, health professionals are being exposed to radiation in their work environment while conducting diagnostic or therapeutic procedures. Approximately 7 million medical radiation workers worldwide including India, are being exposed to low levels of occupational radiation throughout their reproductive age. Animal and human studies have convincingly documented that occupational radiation exposure can cause genomic instability, alter cellular and humoral immunity and even impair fertility in males. However, till now the effects of occupational radiation exposure on sperm functional characteristics, genetic and epigenetic integrity are not elucidated.

The present study included 134 subjects in which 83 subjects were exposed to ionizing radiation at their workplace during diagnostic or therapeutic procedures. Semen characteristics, DNA damage, methylation status and incidence of sperm aneuploidy in the exposed subjects were analyzed. In addition, plasma antioxidants, lipid peroxidation and reproductive hormone level in the exposed subjects were also estimated from the peripheral blood. Parallely, chromosomal abnormalities in the peripheral blood lymphocyte were also assessed in the radiation exposed and non-exposed controls.

Evaluation of ejaculate from the radiation exposed subjects showed a significant reduction in the sperm motility, viability, and normal morphology compared to age matched non-exposed individuals. Specifically, the incidence of sperm head vacuoles was significantly higher in the exposed subjects compared to non-exposed controls. An inverse relationship was established between the extent of radiation exposure and sperm
characteristics such as motility and viability. Since ionizing radiation is known to induce DNA damage, spermatozoa from the exposed subjects were assessed for the DNA fragmentation by TUNEL, SCSA and Comet analysis. The level of sperm DNA damage as assessed by comet and SCSA was significantly higher in the exposed subjects in comparison to non-exposed individuals. An attempt to study the influence of occupational radiation exposure on global methylation demonstrated a significant increase in the level of hypermethylated spermatozoa in the ejaculates of radiation exposed subjects compared to non-exposed subjects. The level of seminal plasma antioxidants such as GSH and TAC was significantly higher in the exposed subjects compared to non-exposed. Similarly, blood plasma antioxidants such as GSH, TAC and SOD were significantly higher in the radiation exposed subjects compared to non-exposed individuals. In contrast, extent of lipid peroxidation as assessed by the MDA level was not different in both seminal and blood plasma of radiation exposed and non-exposed subjects. The increase in antioxidant level in both seminal and blood plasma could be an adaptive measure to tackle the oxidative stress to protect genetic and functional deformities in radiation health workers. Since the occupationally exposed subjects showed abnormalities in the semen characteristics, an attempt was made to determine the association between change in the levels of serum reproductive hormones and exposure level in the subjects. However, there was no difference in the level of reproductive hormone such as FSH, LH and testosterone in radiation exposed subjects compared to non-exposed controls. These findings suggest that semen abnormalities observed in the radiation exposed subjects are not mediated through endocrine disrupter. Overall, the observations made in this study demonstrated an increase in the sperm
nuclear abnormalities and altered methylation pattern in radiation exposed subjects which raises the concern on hazardous effect of occupational radiation exposure on germ cell abnormalities.

The present study is unique in its examination of the possible influences of occupational radiation exposure. The strengths of the present study are: a) the use of highest number of exposed subjects than any of the earlier reports on radiation exposed health workers, b) simultaneous evaluation of functional, genetic and epigenetic integrity of male gametes, c) assessment of antioxidants and lipid peroxidation levels in both seminal plasma and blood plasma together and d) simultaneous evaluation of chromosomal abnormalities in the peripheral blood lymphocyte which can serve as an internal control. Further, selection bias is unlikely since the age of the subjects did not differ between two groups and the non-exposed subjects were recruited from other departments of the same hospitals. Though semen abnormalities are clearly evident in the exposed subjects, the incidence of infertility and abnormal reproductive outcomes in the spouses of exposed subjects were not significantly evident possibly due to limited sample size. Hence future studies are needed in large population to address the reproductive fitness of the exposed individuals and also the health status of the children born to radiation exposed health workers.