Malignant bone tumors (MBT) such as Osteosarcoma and Ewing sarcoma accounts for 3% to 8% of all cancers in paediatrics and young adults. Up until the 1970s, amputation was the only available treatment for MBT. While currently, care includes a combination of treatment including neo-adjuvant therapy, chemotherapy and surgical excision via (a) bone allograft, (b) prosthesis, and (c) ECRT. Each of the methods is important from clinical viability but has its own disadvantages such as limitation of donor and/or bone bank, cost, possibility of multiple surgeries and affordable high-quality prosthesis. In such a scenario, to use Extra Corporeal irradiation and Reimplantation Therapy (ECRT) as a biological reconstruction technique of limb salvage surgery for MBT patients offers cutting edge advantages. The “implant” being patient’s own bone is by default “patient-specific” with low risk of immunological reaction. ECRT, which was introduced in 1968 by Spira and Lubin is now an established technique actively employed in Europe and Asia. ECRT is the only available treatment in many cases such as under low-resource, and absence of the bone bank. ECRT included typical radiation dosage varying from 50Gy to 300 Gy to control or kill malignant cells. Such intentional radiations are found to be responsible for alterations in bone properties. For complete evolution of ECRT, various parameters affecting structure-function relationship needs to be considered.

Ample amount of clinical studies have been done on ECRT. However, to the best of our knowledge limited investigation exists to understand bio-mechanical response of bone post single high-dose radiation and that too on human bone. The present study is one of its kinds since it involves investigation directly on human samples. Here, 15 patients undergoing
ECRT therapy at the Department of Orthopaedic, All Indian Institute of Medical Sciences (AIIMS) Delhi, India were enrolled for the study. Here, changes in strength, composition and microstructure in the bone of patients subjected to ECRT are investigated. The micro-scale response of human bone pre-irradiation was compared with its corresponding post-irradiation response. In particular, mechanical properties of bone were investigated using instrumented indentation while surface deformation and time-dependent response were determined using Atomic Force Microscopy (AFM). The observed micro-scale mechanical response was compared and analyzed in the light of compositional behaviour obtained via Raman spectroscopy. The changes in the bone microstructure particularly bone mineral density and porosity after post-irradiation were quantified using micro-computer tomography (µ-CT).

Current work leads to the conclusion that due to irradiation there is an overall reduction in indentation modulus and hardness. Subsequently, increase in deformation, viscous response, and energy dissipation across all samples were found. The changes in mechanical properties were found to be consistent with compositional changes, where mineralization and amount of calcium content was found to be decreased. It was observed that radiation induces upto 50% decrease in amount of mineralization. Demineralization due to radiation is a major phenomenon governing the elastic stiffness and plastic deformation under single dose of 50 Gy radiation. In addition, the microstructural study via micro-CT also parallel’s the compositional and mechanical findings. It establishes that bone mineral density is reduced while tissue becomes more porous post-irradiation. The study not only provides insight into bone alteration mechanism post ECRT, but also provides a quantitative value to deterioration of patient-specific bone, which can be of higher importance to clinicians in post-operative care management and ultimately to improved patient-specific outcome.