Extracorporeal Irradiation (ECI): An Overview

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Abstract:

Extracorporeal irradiation (ECI) of the bone is used in the management of malignant bone tumour (MBT). It consists of surgical removal of the tumour-bearing bone segment from the body followed by removal of the tumour and soft tissue from the bone followed by high dose irradiation of the bone and re-implantation of the sterile bone back into the body. Since radiation is delivered to the bone segment outside the body, the usual radiation-related side effects do not occur, resulting in better compliance. We report a case of ECI in the management of a malignant bone tumour and provide an overview of the ECI technique. Based on our study, ECI provides a viable alternative to amputation, enabling patients to preserve their limbs and maintain a good quality of life. Overall, ECI is a valuable treatment option for orthopaedic and radiation oncologists for managing primary MBTs with good functional outcomes and short-term survival rates.

Key words: ECI, Limbs Preservation Surgery, Autografts, Malignant Bone Tumour, Osteosarcoma.

Introduction

Radiation given outside the body to kill the tumour cells in the bone is called extracorporeal radiotherapy (ECRT).[1-3] It is a method that is used in the management of malignant bone tumours (MBT). It was first reported by Spira *et al.* in 1968, where ECRT was used for the first time in management of MBT.[1,2] Extracorporal irradiation (ECI) consists of en-block resection of tumour bearing bone segment, removal of tumour from the bone, irradiation and reimplantation back into the body. Malignant bone tumours can be treated either with limb salvage surgery or by surgical amputation. Limb salvage surgery is a procedure that helps to preserve the limb by removing the part of bone involved with the tumour and the surrounding tissues. In the majority of cases treated with limb salvage surgery, biological methods of reconstruction are used, where the patient's own bone can be saved after irradiating it.

Material & Methods

MBT patients were studied, and patients with histopathological proof of malignancy and no evidence of distant metastases were considered suitable for limb preservation therapy (LPT). A clinical examination was done in detail by an orthopaedic surgeon, medical oncologist and radiation oncologist. All investigations such as haematological tests (e.g., liver function tests [LFTs], kidney function tests [KFT]), x-rays, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET) scan were done according to a standardised protocol to assess the local extent of the disease and distant metastases.

During a single session of ECI, a dose of, 50 Gray (Gy) was delivered using 6 megavolt (MV) photon energy. Two parallel opposed antero-posterior fields were used. The radiation field size was chosen to ensure adequate coverage of the bone segment. The radiation duration was approximately 25-30 minutes.

Parameters defining the ECI treatment are:

Field size: X=8, Y=22.7
Gantry angle: 0° & 180°
Collimator angle: 0
Dose rate: 600 cGy/min
Monitor units (MU): 2446 MU
Energy: 6 MV Photon

Techniques of ECI

Limb preservation surgery was planned about four weeks after completion of the neoadjuvant chemotherapy. The size of the tumour was marked, and the amount of bone to be removed

was planned. Intraoperatively, the affected bone segment was removed, and frozen sections were taken from the proximal and distal ends of the bone. The resected specimen was then transferred to a separate sterile trolley under all aseptic precautions. The bone specimen was then washed with pulse lavage to remove all the soft tissues from the bone. Afterwards, tibia tumour bone was packed with vancomycin-soaked mops to reduce the risk of infection (Figure 1). The bone segment was tightly wrapped in multiple layers of drapes to avoid air gaps that would affect homogenous radiation dose delivery. The bone segment was sent to the radiotherapy department in a sterile condition.

Figure 1: Packing of the bone segment with vancomycin-soaked mops, wrapped in multiple layers in a sterile condition.

A dose of 50 Gy radiation was given during a 30-minute duration using 6 MV photons with parallel opposing fields to kill all the tumour cells (Figure 2). The segmented bone was transferred back to the operation theatre (OT) under sterile conditions. The bone was then reimplanted with fixation devices, with or without a vascularised autologous bone graft. The advantages of re-fixation with the same bone is that it provides an exact match to the resected bone which is now tumour-free.

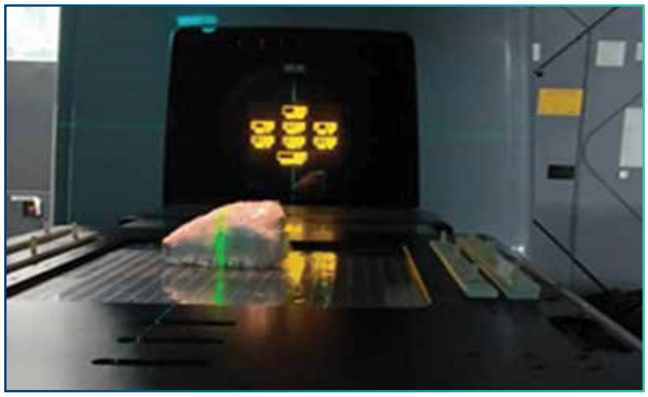

Figure 2: The resected bone irradiated with 50 Gy for a duration of 25-30 minutes.

Discussion

MBTs are relatively rare but occur more frequently in children and adolescents because of their active skeletal growth.[2,3] Due to recent advances in imaging, pathological, surgical techniques, chemotherapy and radiation therapy, management in most cases now favour limb preservation therapy (LPT) over amputation. The main aim of LPT is to completely resect the tumour and to maintain limb function. This involves reconstructive procedures by using either bone grafts or prosthesis.[2] ECI is a convenient and a cost-effective way of LPT.[2-6] ECI involves *en bloc* removal of the tumour-affected bone segment, irradiation of the bone segment and reimplantation of the tumour free bone segment back in the body. This allows the delivery of very high doses of radiation to the tumour bed, which would otherwise not be possible. This high dose, ranging from 50-300 Gy is not only lethal to all tumour cells, but also diminishes the chances of recurrence.[2,5-7] The other advantages of ECI include the ability to deploy an anatomically size-matched graft for reconstruction. It has a psychological advantage as the patient feels that their own bone is being used as prosthesis. It is also more cost-effective. ECI is now being used to treat primary malignant bone tumours like osteosarcomas — aggressive tumours that affect the metaphysis of long bones. In such cases ECI proves to be beneficial, especially when complete surgical resection of the disease cannot be done.[8,9]

We had a histopathological proven case of MBT without any evidence of distant metastasis. The case was discussed in tumour board and planned for limb preservation treatment i.e., neoadjuvant chemotherapy followed by surgery along with ECI. The patient received a single high dose of 50 Gy of extracorporeal radiation by using 6 MV photon energy. The patient was followed for a period of five months, after which the metals plates were removed (Figure 3).

Figure 3: Postoperative follow-up after duration of five months and removal of metal plate.

Conclusion

ECRT is a new limb salvaging procedure that is increasingly being used. ECI has several advantages, including a precise anatomical fit of reimplanted bone segment, preservation of joint mobility, no issues of allograft rejection, less or no risk of disease transmission or immunological reaction, and ready availability of bone.[6-8] Limitations of ECRT includes its unsuitability for bones that are structurally weak or have pathological fractures. Additionally, the overall duration of the surgery is increased. ECI is technically feasible in the management of MBT and provides decent local control and short-term survival rates. ECI is a convenient alternative to prosthesis from a health economic point of view. Further studies with larger sample sizes and longer follow-up periods are needed to improve our understanding of outcomes such as graft rejection rates, infection rates (including comparisons between ECI and prosthetic reconstruction), limb length discrepancies, and the patient's overall quality of life.[10]

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References

1. Puri A, Gulia A, Agarwal M, *et al.* Extracorporeal irradiated tumour bone: A reconstruction option in diaphyseal Ewing's sarcomas. *Indian J Orthop.* 2010;44(4):390-6.
2. Sharma DN, Rastogi S, Bakhshi S, *et al.* Role of extracorporeal irradiation in malignant bone tumours. *Indian J Cancer.* 2013;50(4):306-309.
3. Agarwal S, Rathi AK, Singh K, *et al.* Extracorporeal irradiation in malignant bone tumours: Single institution experience and review of literature. *J Cancer Res Ther.* 2023;19(Suppl):S1-S5.
4. Shah MR, Shah MM, Agrawal AK, *et al.* Intra-operative extracorporeal radiation therapy for skeletally immature patients with malignant bone tumours. *SA Orthop J.*. 2021;20(1):43-8.
5. Perlaky T, Kiss J, Szalay K, *et al.* Extracorporalis irradiatio: nagy csontdefektussal járó tumourresectiót követő biológiai rekonstrukció [Extracorporeal irradiation: biological reconstruction following tumour resection with a large bone defect]. *Orv Hetil.* 2020;161(45):1914-1919. Hungarian.
6. Krieg AH, Lenze U, Schultze L, *et al.* Extracorporeal irradiation and reimplantation of tumour-bearing bone segments following diaphyseal sarcoma resection at the tibia. *Anticancer Res.* 2019;39(4):2015-23.
7. Gohil KM, Misra S, Venkataswamy Reddy J, *et al.* The role of extra-corporeal radiation therapy for osteo-sarcoma. *Bioinformation.* 2024;20(10):1329-1335.
8. Zhang S, Wang XQ, Wang JJ, *et al.* En bloc resection, intraoperative extracorporeal irradiation and re-implantation of involved bone for the treatment of limb malignancies. *Mol Clin Oncol.* 2017;7(6):1045-1052.
9. Agarwal MG, Gundavda MK, Gupta R, *et al.* Does extracorporeal irradiation and reimplantation after acetabular resections result in adequate hip function? A preliminary report. *Clin Orthop Relat Res.* 2018;476(9):1738-1748.
10. Kancherla NR, Paruchuri S, Arvind B, *et al.* Our experience with extracorporeal irradiation and reimplantation of the irradiated bone for the reconstruction of bone defects following tumour resection. *Cureus.* 2024;16(1):e52853.