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RESEARCH ARTICLE

STANDARDIZATION OF FBX DOSIMETER WITH COMPUTERIZED TREATMENT PLANNING SYSTEM (TPS)

[1,*]Manjusha B. Kothawade and [2]Balraj, A.

[1]Dept. of Physics, Dr. D. Y. Patil Arts, Commerce and Science College Akurdi, Pune 411044
[2]Medical Physicist Scientist -'F' (DRDO) Command Hospital (SC) Pune, India

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ABSTRACT

FBX dosimeter is mainly based on the determination of the radiation dose from the chemical changes produced in an irradiated medium, which can be measured by Spectrophotometer or Colorimeter, for which adequate FBX solution is required for measuring the optical density (OD). In present study, we measured the entrance and exit dose in the carcinoma patient's body surface during the radiation therapy using FBX dosimeter. These findings were compared with computerized treatment planning system.

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INTRODUCTION

The Ferrous sulfate – Benzoic acid – Xylenol orange (FBX) is a modified Fricke dosimeter developed by Gupta and co-workers in the 1970s to increase the sensitivity of low level doses. The measurable range of the FBX dosimeter is from 1 cGy to 3000 cGy. The ferric ions form a colour complex with xylenol orange, resulting in a colour change of the solution. This change in colour is measured by spectrophotometer at about 540 nm as an estimate of the ferric ion yield. One of the important properties of this dosimeter is its energy-independent response for X-rays and gamma rays from 33 keV to 1250 keV. In many radiotherapy centres in vivo dosimetry with semiconductor detectors is a commonly used technique to assess the delivery dose at the moment of the irradiation. The measured dose is mostly the entrance dose, which is usually compared to the expected dose as predicted by the TPS (Troulis, 2002). Any discrepancy between the measured entrance dose and the expected entrance dose can be caused by errors in patient set-up in the number of monitoring units or variation in the irradiation time, beam output variations etc. At present, these errors are oftenly eliminated by using a check and confirm system. The remaining errors passed over by check and confirm system can be detected by in vivo entrance dose measurements and possibly corrected before the next irradiation sessions (Semwal, 2005). At present, the exit doses are less frequently measured. In routine quality assurance programmes, exit dose provides interesting information about tissue thickness and tissue inhomogeneities through which the beam passes. Tissue inhomogeneities, in particular when not taken into account by the treatment planning system, explain some deviations observed by in vivo exit dose measurements. Using combined entrance and exit dose measurements, one can measure the modifications of the overall transmission caused by the presence of bones, air or soft tissues as compared to the values calculated assuming the patients to be water equivalent. Ultimately these in vivo dose measurements could be used for quality control of the treatment planning system. However, the most important figure of merit is neither entrance dose nor the exit dose, but the dose effectively delivered to the target volume. Therefore the dose delivered at the target volume has been measured by using the FBX dosimeters and the same was compared with TPS dose distributions. The advantage of the FBX system is its water equivalent composition, average volume dose measuring capability, and energy and temperature independent response as compared to TLD or semiconductor dosimeters. However, detailed studies will be needed with regards to its safety before actual in-vivo dose measurements are possible with the FBX dosimeter (Elder *et al*., 1995). A new inverse treatment planning system (TPS) for external beam radiation therapy with high energy photons is commercially available that utilizes both dose-volume-based

******Corresponding author:* **Manjusha B. Kothawade,**
Dept. of Physics, Dr. D. Y. Patil Arts, Commerce and Science College Akurdi, Pune 411044

cost functions and a selection of cost functions which are based on biological models (Semenenko *et al*., 2008).

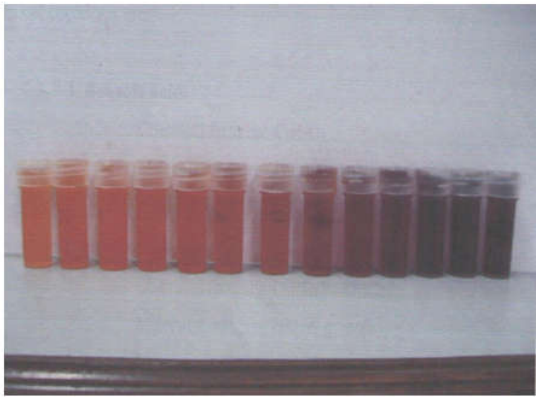
Aims and Objectives

- To determine the dose delivered at the target in carcinoma patients by using the FBX solution filled polypropylene tubes (PTs).
- To compare the dose measured by the FBX dosimeter at a point in the target volume to the Treatment Planning System (TPS) dose distributions at the target volume.

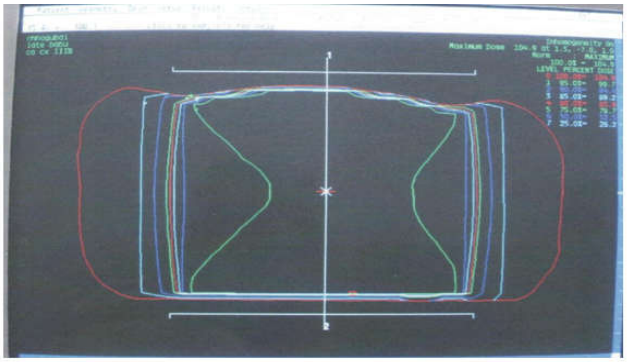
MATERIALS AND METHODS

Using distilled de-iodinized water FBX dosimetric solution was prepared by following standard method mentioned in literature (Gupta *et al*. 1982). The FBX dosimeters developed have been used for dose measurements in patients as an in-vivo dosimetry. Total 5 carcinoma patients were selected for this study. The FBX solution is filled in plastic vials to irradiate by gamma rays using Theratron 780 E cobalt 60 unit (Gupta *et al*., 1982; Gupta *et al*., 1992; Moussous *et al*., 2011). The patient had been positioned at the simulator Simulix HP 1200 for treating target region. Field size, gantry, collimator angles, source to skin distance, depth of the tumour, isocentre, were set to treat the desired volume of the tumour. The vial is kept in front of head of machine in such way that the one vial is at entrance and another one at the exit of dose. All 5 patients were treated by conventional fractionation of 90 c Gy or 100 c Gy per fraction in target region (Gupta, 1973) (tumour at isocentre) (Gupta *et al*., 1982). After irradiation to particular dose the irradiated solution from the vial is transferred to glass vial to measure the optical density using colorimeter at 540 nm. The OD measurements are carried out after 30 minutes of the irradiation because it requires the time to complete its reaction.

These patients were taken for the study of determination of the dose delivered at the target by using Treatment Planning System (TPS) and dose calculated by manual method, and this was also compared with the measured dose by using FBX dosimeters. The Treatment Planning System (TPS) manufactured and supplied by Muhi Data USA and Simulator Simulix HP 1200, manufactured and supplied by Nucletron, The Netherlands, were used for treatment planning and treatment simulation. Treatment volume and target volume of dose distributions were calculated with the above simulation and treatment planning by using the TPS.



Plastic vial filled with solution after irradiation

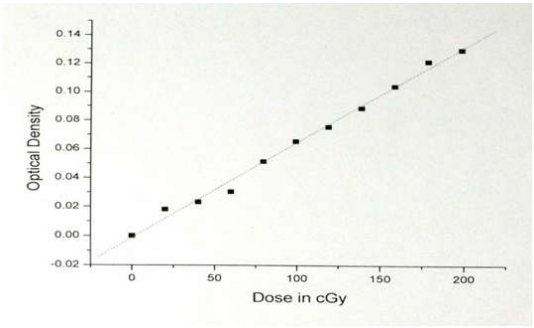


Distribution of dose by treatment planning system (TPS)

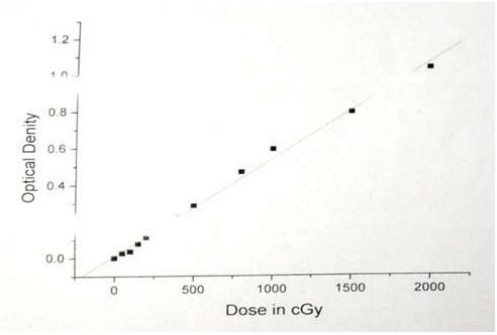
RESULTS AND DISCUSSION

Calibration curve

To plot a calibration curve (Madhvanath *et al*., 1976; Mhatre *et al*., 2012) we filled the plastic vials with FBX solution & irradiated it for known different values of dose then measured its OD using colorimeter & plotted a curve for OD vs Dose. Here we irradiated the solution for high dose (0 cGY – 2000 cGy) and low dose (0 cGY – 2000 cGy). We get the linear relationship between OD & Dose.



1. Calibration curve of FBX dosimeter for low dose



2. Calibration curve of FBX dosimeter for high dose

From these calibration curves unknown dose can be measured.

Dose by treatment planning system

In DSS software, after filling all information of patient like name of patient, site of tumour etc. it allows us to draw contour. Then asks about depth of tumour, beam energy, collimator opening etc. After selecting beam it calculates the dose distribution over entire region. In this way using TPS we can obtain the dose absorbed by patient.

Table 1. The comparison of dose obtained by FBX dosimeter & TPS

Name	Dose Location	Dose obtained by calibration curve (cGy)	Dose obtained by treatment planning system (cGy)
Patient 1	Entrance	107.084	104.9
	Exit	27.46	26.2
Patient 2	Entrance	143.405	134.8
	Exit	35.844	34.1
Patient 3	Entrance	206.26	196.2
	Exit	52.19	49.3
Patient 4	Entrance	206.26	196.45
	Exit	65.177	56.71
Patient 5	Entrance	142.521	135.23
	Exit	39.673	36.4

Conclusion

- The main advantage of the FBX point dosimeter is that it can be easily prepared in the hospital itself and its cost is many times lesser than the other dosimeters. Due to its affordability, it can be used even in rural hospital and under-developing countries. It is cord-less, temperature, pressure and energy independent and patient and operator friendly. Its accuracy is better than any other dosimeter.
- The variation between measured values of FBX dosimeter and TPS are in the range of 2.18% to 6.38%.
- For more accurate dosimetry it is always better to compare FBX dosimeter as well as TPS dose values.

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