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An institutional experience of quality assurance of a treatment planning system on photon beam

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ABSTRACT

Aim: The purpose of the present study is to show the application of the IAEA TRS-430 QA procedures of Eclipse^{TM}v7.5 TPS for photon energies. In addition, the trends of the deviations found in the conducted tests were determined.
Background: In the past, the lack of complete TPS QA procedures led to some serious accidents. So, QA in the radiotherapy treatment planning process is essential for determination of accuracy in the radiotherapy process and avoidance of treatment errors.
Materials and methods: The calculations of TPS and measurements of irradiations of the treatment device were compared in the study. As a result, the local dose deviation values (δ_1: central beam axis, δ_2: penumbra and build up region, δ_3: inside field, δ_4: outside beam edges, $\delta_{50\text{–}90}$: beam fringe, RW_{50}: radiological width) and their confidence limit values (including systematic and random errors) were obtained.
Results: The confidence limit values of δ_4 were detected to increase with expanding field size. The values of δ_1 and δ_3 of hard wedge were larger than open fields. The values of δ_2 and $\delta_{50\text{–}90}$ of the inhomogeneity effect test were larger, especially than other tests of this study. The average deviation was showed to increase with the rise of the wedge angle. The values of δ_3 and δ_4 of lung irradiation were outside tolerance.
Conclusions: The QA of TPS was done and it was found that there were no reservations in its use in patient treatment. The trend of the deviations is shown.

1. Background

In recent years, complexity of TPS has increased significantly and this has led to the requirement for a comprehensive quality assurance (QA) guidelines. Increased attention has been paid to quality assurance of treatment planning systems by many researchers,[2,3,6] several national and international organizations.[1,4,5,7]

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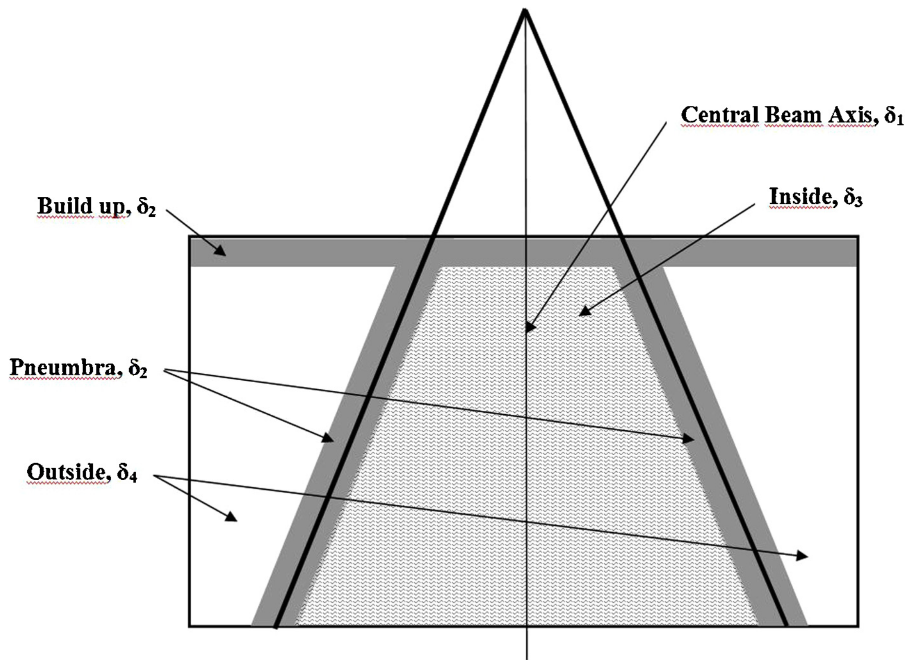

Fig. 1 – Definition of different regions in a radiation beam, based on the magnitude of the dose and dose gradient (adapted from Ref.[8]).

accuracy in the radiotherapy process and avoidance of treatment errors.[1]

1.1. *QA guidelines*

A number of task groups[1,5,8] over the past several years have developed guidelines and protocols for systematic QA of 3D radiotherapy treatment planning systems (TPSs), including specific QA aspects of a TPS, such as anatomical description, beam description, dose calculations, and data output and transfer. Many studies have been performed to address specific problems associated with treatment planning and dose calculation procedures.[9–12] Some studies[13–16] were related to the performance of a specific TPS.

The general requirements of QA of TPS in radiotherapy have already been discussed in the literature.[1–3] Some reports[1–4] have been published to help physicists in the implementation of a comprehensive QA program. Comprehensive report of IAEA for QA is called TRS-430 report.[1]

TRS-430 report[1] includes four steps of QA program; acceptance tests, commissioning, periodic QA program and patient specific QA. The acceptance test is applied to verify functionality and quantity agreement with the specification report attached by manufacturer. The commissioning consists of two different processes. One includes dosimetric study to verify the performance of the dose calculation generated by the TPS. The others are non-dosimetric verifications to verify the functionality of the tools of TPS. Periodic QA program is implemented to verify reproducibility of planning in accordance with that established at commissioning. Patient specific QA is performed to verify the treatment process as a whole.

1.2. *Criteria of acceptability*

AAPM TG 53 report[5] and several researchers[2,17,18] have defined different criteria of acceptability of various regions that can be defined in terms of dose and dose gradient in a photon beam, as shown in Fig. 1. Venselaar et al.[17] has defined a set of criteria of acceptability based on different tolerances for δ (local dose deviation) based on the knowledge that dose calculation algorithms provide a better accuracy in the high dose and small dose gradient region of the beam than in others. These reports[2,5,17] have proposed different tolerances for the various regions in a photon beam, as given in Table 1.

Deviations between results of calculations and measurements can be expressed as a percentage deviation of the local dose according to Venselaar et al.[17]

$$\delta = 100\% \times \left(\frac{D_{cal} - D_{meas}}{D_{meas}}\right) \quad (1)$$

where D_{cal} and D_{meas} are calculated dose at particular point in the phantom and measured dose at the same point in the phantom, respectively. In low dose regions where the points were outside the penumbra or under a block, an alternative comparison was made accordingly to Venselaar et al.[17]

$$\delta = 100\% \times \left(\frac{D_{cal} - D_{meas}}{D_{meas,cax}}\right) \quad (2)$$

where $D_{meas,cax}$ is dose measured at a point at the same depth on the central axis of the open beam. If a study consisting of many points is evaluated, some statistical assessment can