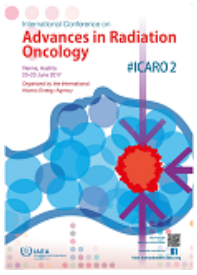

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Analysis of setup incertanties generated in 6D ExacTrac X-Ray system for patients in hypofractionated treatments of intracranial radiosurgery

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Introduction

With the growing technology in radiotherapy, the complexity of treatment planning has been increasing and higher doses have been delivered to tumor, so it is necessary to assess the accuracy of patient setup in order to guarantee better compliance of tumor with greater protection of healthy tissues. To achieve this goal, image guided radiotherapy (IGRT) is mandatory role, especially for hipofrationated treatments, such as cranial radiosurgery.
The ExacTrac X-Ray 6D BrainLAB is an IGRT system that uses an infrared (IR) system for pre-positioning, robotic table with six degrees of freedom and two orthogonal X-rays tubes for imaging.
Using IGRT it is possible to reduce PTV margin to minimize dose delivered to normal tissue, but it is necessary to reduce setup uncertainties.
These uncertainties can be separated into random and systematic errors. A systematic error may be understood as an average variation occurred during the treatment. A random error on the other hand, can be defined as the dispersion of systematic errors over time of treatment.
The purpose of this study is to evaluate setup uncertainties for patients treated with radiosurgery intracranial hypofractionated using IGRT with ExacTrac.

Materials and Methods

Exactrac System

Treatments localization based on the ExacTrac X-Ray 6D system includes two steps: a pre-positioning using IR and X-ray verification images. The IR component has two emissors of IR waves and two cameras installed on the ceiling to read the signal that is reflected by reflective beads distributed on the surface of the patient or on a localization box. Using this information an automatic setup can be easily determined by moving the table to coincide with the positioning marks determined by the CT image.
The X-ray component consists of two orthogonal X-ray tubes installed on the floor and two panels on the ceiling. Two orthogonal X-rays images are obtained and compared with reference bone anatomy using automatic fusion to DRR images generated by exactrac software. The result of comparison gives the setup uncertainty in six degrees of freedom: three translational and three rotational.

Treatment

We evaluated 36 patients treated with intracranial hypofractionated radiosurgery from August 2015 to October 2016 in a Varian linear accelerator 6EX. The dose prescribed was 25-30 Gy in 5 fractions for 30 patients and 12-18 Gy single fraction for 6 patients.
Immobilization of the patient was taken with BrainLab masks. This mask is comprised of three reinforcement strips of thermoplastic material arranged in the forehead, nose and chin. The treatment isocenter were prelocalized using the localization box and correct the positioning after taken X-Ray images. The first image deviations were not considered in the analysis.
During the treatment, in each angle of table it was taken images and the variations calculated were corrected if it was outside limits acceptable range (0,7 mm for translation and 1° for rotation). The corrections were recorded for future analyses.

Deviations generated in the translational coordinates (vertical, lateral and longitudinal) and rotational (roll, pitch and yaw) were analyzed and expressed in terms of mean values and their standard deviations. The random error distribution (RMS(σi)),variation in systematic error (Σ(μi)) and overall distribution of setup corrections (Σoverall) were determined as presented by Infusino, Erminia et al.

Results

We had a total of 656 X-Ray images. All these measurements were used to calculate the errors presented on Table 1.

The systematic error in the lateral, longitudinal and vertical was very small, 0.14, 0.26 and 0.15 mm respectively. Random component was a little larger, ranging from 0.3 to 0.6 mm, probably because small internal movements of the brain, fixation power of the mask, inaccuracy of the fusion algorithm of the Exactrac, inclusion or exclusion of certain anatomic features, inter-observer variation in the interpretation of daily images. The maximum overall error was 0.6 mm. Additionally, the rotational correction were relatively small, ranging from 0.1 to 0.6º.
The 3D vector could be calculated for the translational components, the value found was 0.9 mm.

Conclusions

The magnitude of the random, systematic and overall errors was quantified. The random component was larger than systematic one, opposite to that expected by the literature, showing as the Exactrac system is able to reduce the magnitude of systematic errors, so that the random error demands a little more attention, even because this kind of error is naturally difficult to minimize. But, even with larger random errors, the value of the 3D vector was sub millimeter (0.9 mm). This study emphasizes the importance of daily IGRT and the importance of monitoring setup error for treatments with high dose per fraction.

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