Comparing MLC positioning errors in Clinac and Truebeam Linacs by analysing log files

1J. Olascogorta 1, J. Gago 1, A. Yazquez 1, S. Pellejero 1, C. Eto 1, M. Ayala 1, P. Enunsa 1
2Clinica IMQ Zorrotzaurre, Radiation Therapy, Bilbao, Spain
3Complejo Hospitalario de Navarra, Medical Physics, Pamplona, Spain

Purpose or Objective: Log files contain information about Varian accelerators deliveries of dynamic treatments. This information includes actual and expected leaf positions throughout the treatment. Log files have been proposed by several authors to evaluate leaf position errors. In this study, log files of Clinac (dynalogs) and Truebeam (trajectory log files) accelerators have been analyzed to compare leaf positioning errors of dynamic treatments in different generations of clinical linear accelerators.

Material and Methods: More than 30000 log files have been analyzed, coming from four Clinac accelerators (one Trilogy, two Clinac 21EX, one Clinac 2100CD equipped with Millennium 120MLC) and one Truebeam accelerator (Truebeam STx 2.0 equipped with HD 120 MLC) of three different institutions. Analyzed Truebeam log files correspond to VMAT and dIMRT treatments whereas Clinac log files only correspond to dIMRT treatments. Clinac accelerators control system has approximately a 50ms delay (one control cycle time). At each control cycle, MLC controller compares the planned to the actual positions. But in this comparison, the actual position is delayed 50 ms from the planned one. This effect causes that measured positions appear in dynalogs one cycle out of phase with respect to the planned positions. Therefore, error statistics present an error component proportional to leaf speed. A recent research of our group has studied this effect and, as a result, we have proposed to calculate error statistics without time delay effect to evaluate the MLC positioning deviations. In Truebeam accelerators this effect does not exist due to the proactive design of the MLC control system.

Leaf positioning RMS errors and 95th percentile errors were calculated to evaluate MLC performance with and without time delay effect. Log files were analyzed using an in-house Matlab program.

Results: In Clinac accelerators, the mean RMS error was 0.35, 0.34, 0.33 and 0.29 mm for each linac. The mean 95th percentile error was 0.62, 0.61, 0.62 and 0.58 mm. Without time delay effect, the mean RMS error was 0.038, 0.042, 0.040 and 0.026 mm for each linac. The mean 95th percentile error was 0.054, 0.057, 0.057 and 0.046 mm.

In Truebeam accelerator, the mean RMS error and the mean 95th percentile for VMAT treatments were 0.038 mm and 0.07 mm. For IMRT treatments, the mean RMS error and the mean 95th percentile were 0.027 mm and 0.052 mm.

Conclusion: Truebeam MLC positioning errors are substantially lower than those of Clinac machine models, mainly due to the proactive design of Truebeam control system. However error statistics without time delay effect in Clinac machines, have the same order of magnitude of Truebeam ones.

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Regular assessment of isocentre and positioning accuracy in image guided stereotactic radiotherapy

C. Heinz 1, S. Neppel 1, W. Haimert 1, C. Belka 1, M. Reiner 1
1Ludwig-Maximilians-University, Department of Radiation Oncology, Munich, Germany

Purpose or Objective: As the number of stereotactic radiotherapy applications is increasing and image guided techniques are superseding frame based solutions in cranial as well as in extracranial stereotactic applications the need to include imaging and positioning devices in the regular quality management is obvious. A very common test to check the deviation between the radiation isocentre and the room lasers is the Winston-Lutz test. However, this test lacks significance in combination with image guided stereotactic treatment since the patient is positioned by the image guidance devices rather than by the room lasers. The purpose of this project was, to implement a practical workflow to assess the isocentre and positioning accuracy of image guided stereotactic applications.

Material and Methods: The concept of our approach is based on the Winston-Lutz test except that positioning is done automatically by the image guidance devices rather than by the room lasers. Therefore a pelvis phantom including a metal sphere is roughly positioned on the treatment couch. By the use of an image guidance device (e.g. CBCT, non-coplanar imaging) translational and rotational correction values are acquired and sent to a 6-DOF robotic couch. After the phantom position is adjusted by movements of the robotic couch, the metal sphere inside the phantom should be positioned exactly at the radiation isocentre of the linear accelerator. The result of the image guided positioning is recorded by portal images. For this purpose a small radiation field (2x2 cm²) is applied from up to 8 different gantry angles. Afterwards the radiation field isocentre, the isocentre position of the metal sphere as well as the deviation is calculated by a software that was developed in-house.

Results: This end-to-end test provides quantitative information on the achievable positioning accuracy of an image guided stereotactic application in the clinical situation. Besides, the deviations of the radiation isocentre from the mechanical isocentres of the gantry, collimator and couch can be analyzed using the same setup. The test is not restricted to a specific image guidance modality.

Conclusion: A regular assessment of all systems included in stereotactic patient positioning is highly recommended. Due to the short execution time this test is suitable for regular assessments in the QA routine.

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Implementation of a safety checklist to improve quality and safety of physician plan review process

L. Fong de los Santos 1, S. Park 1, K. Olivier 1
1Mayo Clinic, Radiation Oncology, Rochester, USA

Purpose or Objective: The physician review of the treatment plan upon completion by the treatment planner is a critical clinical process, since it is during this exchange where the physician verifies and confirms the treatment intent. Several near misses in our practice raised the awareness of our group regarding the quality and safety of this process. Moreover, there was no standardization of the review process and no additional safety barrier to detect if the prescription defined by the physician matches the treatment intent. Our goal is to use a safety checklist to improve the quality and safety as
well as the communication dynamics during the plan review process.

**Material and Methods:** A safety checklist was developed and implemented using checklist’s best practices as well as input from physicians, physicists and treatment planners (Figure 1).

**Results:** The safety checklist was used during a period of 6 months across our entire practice: 40 physicians and 24 planners. 1773 treatments plans were reviewed using the safety checklist process. This sample represents close to 95% of all clinical plans done in our practice during this period of time. The safety checklist helped catching 19 near-misses and also helped achieving 99% overall compliance to the plan review process. Pre- and post-implementation surveys shows improvement on communication dynamics and interaction between physician and treatment planner. Upon completion of the PQI, this safety checklist has become our standard operating procedure for the physician plan review process.

**Conclusion:** A safety checklist was successfully implemented as a safety barrier as part of the physician plan review process. The utilization of the safety checklist improved communication dynamics, process compliance and standardization, thus, improving the quality of the review process and the overall safety of our practice. This work presents evidence that Safety Checklists are an effective tool in error management as well as a tool to improve process compliance and team communication.

**Purpose or Objective:** Radiochemotherapy is inherently associated with adverse events and complete, accurate and examiner-independent documentation is essential for everyday clinical work as well as for clinical trials. Acute toxicity during treatment might make it necessary to adapt the current treatment, to interrupt irradiation or to skip or postpone a cycle of chemotherapy. Late effects may become symptomatic even years after treatment has been completed. The common approach to collect toxicity data is to use paper-based documentation which has to be manually fed into databases for evaluation. This method turned out to be time-consuming, error-prone and impractical. In order to address these issues, the software “Toxicity” was developed at the department of Radiation Oncology, Charité Universitätsmedizin Berlin.

**Material and Methods:** The software can be used simultaneously by multiple users on different computers to add, modify or view patient data, treatment information and adverse events. The software supports the National Cancer Institute Common Toxicity Criteria Adverse Event (CTCAE v4.03), Late Effects of Normal Tissue (LENT-SOMA) classification systems, laboratory values and other special data types, e.g. tone audiograms. The user can look up the definition of each item while entering values and get a graphical representation. Data for adverse events is collected every week for acute and every 3 months for late effects. Questionnaires are specific to the tumor entity, body area and treatment. The collected data is stored centrally in a MySQL database and is statistically analyzable. The software was developed in the cross-platform programming language C Sharp and the target platform is Windows, Mac OS X and Unix.

**Results:** To evaluate objective user acceptance, we compared the quality of adverse events documentation in our department between 01/2015 and 06/2015 (paper-based documentation) to the quality of documentation between 07/2015 and 10/2015 (software-based documentation). For patients treated until June 2015 patient files were obtained. Patients who had been treated after July 2015 data from “Toxicity” was automatically exported. In the 4 months the “Toxicity” system was used 7336 items were recorded. We can see a statistically significant increase of information recorded per patient.

**Conclusion:** Our first experience with the “Toxicity” software demonstrates favorable accuracy of adverse events documentation of patients undergoing radiochemotherapy and its applicability as a tool for clinical trials.