# The use of repeat image analysis in radiation therapy as a continuous quality improvement tool

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**Purpose:** Repeat image analysis is an essential assessment tool in diagnostic imaging and is a key component of quality assurance programs[1]. Repeat image rates and causes of repeat images can be used to improve system efficiencies and decrease patient dose. However, there is a lack of published literature on its applicability in radiation therapy. Daily image guidance in radiation therapy has become commonplace with the increased use of intensity modulated treatments, which allow for greater conformity and decreased treatment margins. Although doses from imaging are small relative to the patients' therapeutic doses, dose from imaging should be minimized where possible, particularly in the face of longer life expectancies among the radiation therapy patient population. Repeat images contribute to excess patient dose and require additional time and resources. This study conducted a repeat image analysis within a large radiation therapy department to examine the rate of repeat imaging and to identify the most common reasons for repeat imaging scans.

**Methods:** This retrospective study analyzed the electronic medical records of all radiation therapy patients imaged on 6 conventional linear accelerators, with cone beam CT (CBCT) imaging systems, and 3 computed tomography simulation (CT) units over a 6-month period. Patients' electronic medical records were assessed to determine the addition of unplanned images, and the documented reasons for the repeated images. The repeat rate was calculated by comparing the number of repeated scans to the total number of scans over that time period and is expressed as a percentage of the total number of scans performed. The reasons for repeat images were categorized to identify the most frequent causes.

**Results:** The overall repeat rate for the CBCT units was 4.3%, compared to a rate of 1.2% for the CTs. These are lower than the repeat rates seen in diagnostic imaging which are typically between 5-10%. This is not unexpected since the goal of imaging in radiation therapy is to confirm positioning prior to each treatment and therefore there is greater flexibility in terms of acceptable image quality, positioning and scan technique that will provide the necessary information. The repeat rates are higher on the treatment units than on the CTs since the imaging scan at the CT becomes the reference image and the images at the treatment unit on subsequent days must try to reproduce this setup, meaning there are additional constraints on the cone beam images.

There were variations in repeat rates observed across different units. Figure 1 shows the repeat rates for the 6 CBCT units and for the 3 CTs. Scheduling of patients on the units concentrates similar treatment sites on the same unit. This improves efficiency and expertise on the unit but also results in higher repeat rate on units where anatomical changes are more likely, such as pelvic treatments where bladder and rectal filling contribute to the number of repeat scans.

Reasons for the repeat imaging scans were classified broadly into patient setup errors (anatomical changes, patient motion, patient positioning), image artifacts, and machine errors (iGuide table errors, communication errors and machine termination). There was also a category for cases where there was a repeat image but no reason was documented. In radiation therapy, since the most common anatomical changes are bladder or rectal filling that do not match the planned treatment, these two situations were treated separately from other anatomical changes. Figure 2 shows the distribution of the reasons for repeat scans for CBCT and CT units. The most frequently documented reason for a re-scan was a patient positioning error, following by incorrect bladder or rectal filling. There were also many cases where no reasons for the rescan was documented.

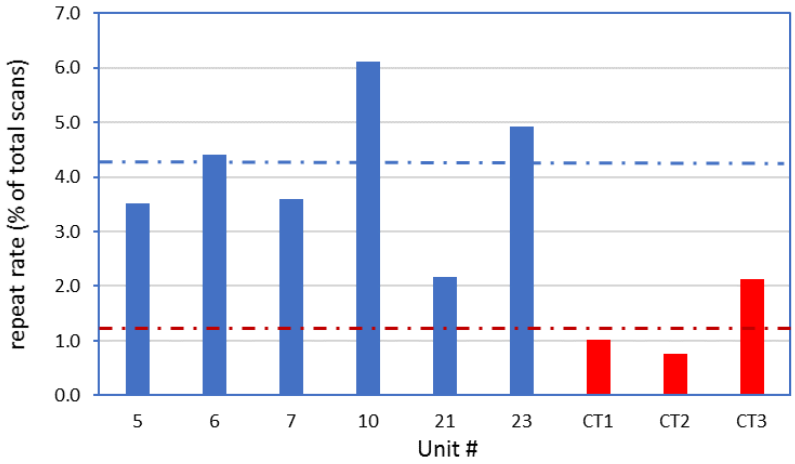


Figure 1: Repeat rates as a percentage of the total number of scans for each unit. The blue bars show the cone beam CT data and the red bars show the CT data. The dashed lines indicate the average repeat rate across all units of each type (blue – cone beam CT, red – CT).

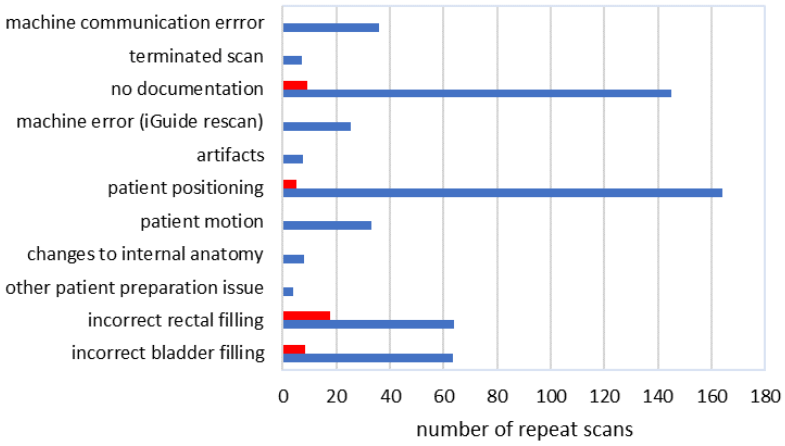


Figure 2: Total number of scans classified into each of the reason categories. Shown in blue for the cone beam CTs and in red for the CTs.

**Conclusions:** Repeat image analysis was successfully applied to radiation therapy imaging. With no published guidance on expected repeat rates, these data will serve as a baseline for institutional quality control initiatives aimed at improving system efficiencies and reducing patient dose.

The high number of repeat scans that had no documented reason shows that improved policies are required so that these data are captured consistently throughout the program. Improved data collection will assist in using the data for future initiatives to reduce the rates of repeat imaging.

**Relevance to CIRMS:**

The stated objective of the CIRMS Medical Applications subcommittee is to identify research and standards needs in the medical community. Radiation therapy comprises a large part of this medical community and is a large user of imaging systems in the diagnostic energy range. In the absence of clear recommendations specific to radiation therapy or published research addressing repeat image rates in the radiation therapy context, this study identifies a gap in the current literature. It demonstrates that repeat image analysis, as used in diagnostic imaging, can be adapted for use in radiation therapy

imaging. The information from the repeat image analysis can provides a starting point and can contribute information on developing standards for repeat imaging in radiation therapy.

The first author is a 3rd Radiation Therapy student with a future in Medical Radiation Sciences and is interested in contributing to the growing field of research in the medical radiation sciences. This study and participation at this conference, which promotes the safe and effective use of ionizing radiation, align with these professional goals.

**References:**

1. A Jones, P Heinz, W Geiser et al. Ongoing quality control in digital radiography: Report of AAPM Imaging Physics Committee Task Group 151. Med Phys 42(11); 2015: 6658-6670