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Clinical Validation of a Filmless Real-Time Independent QA Device for Beam Alignment with Robotic SRS Systems

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Abstract
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Abstract

Objectives:

Beam/isocenter alignment QA, exemplified by the Winston-Lutz test, as an essential procedure in SRS program is often performed with high frequency (daily or weekly). While most modern linear accelerators (linacs) predominantly utilize the on-board Electronic Portal Imaging Device (EPID) for this QA, robotic SRS systems typically lack an on-board EPID. Instead, they rely on independent devices, such as the AQA cube set, which facilitates the capture of orthogonally positioned gafchromic films following image-guided setup. After exposure, these films are scanned and subsequently analyzed using specialized software. This method, however, is time-intensive, expensive due to film costs, and cumbersome, especially when adjustments are needed to maintain system alignment tolerances. To overcome these challenges, we've introduced a cost-effective, film-less, real-time system that significantly enhances QA performance efficiency.

Methods:

The system integrates a digital image-capturing device coupled with real-time alignment analysis software. At the heart of the image-capture device are two fluorescent screens, positioned orthogonally to each other. This arrangement is crucial for capturing the alignment images from two orthogonal angles. To facilitate this dual-angle capture, the device incorporates a combination of reflecting and partially transmitting optics. This optical setup is designed to channel images from two orthogonally projected beams into a single digital camera. Once the images are captured, they are immediately relayed to the accompanying software. This software is equipped with algorithms to calibrate and process the films and promptly provides a comprehensive report on the alignment results. To validate its efficacy, comparative tests between this new system and the existing one have been conducted.

Results:

The QA device was predominantly constructed using 3D printing techniques. Over a three-month testing period, comparative analyses revealed that the average absolute deviation in alignment variations between the new system and the existing AQA system was 0.06 mm, with a standard deviation of 0.05 mm. The range of absolute deviation was observed to be between a minimum of 0.09 mm and a maximum of 0.20 mm. Notably, the QA procedure's duration, inclusive of data analysis, can be reduced by half when compared to the conventional procedure.

Conclusion(s):

The newly introduced beam/isocenter alignment QA system for the robotic SRS is both robust and offers accuracy on par with the current system. The adoption of this new system presents immediate benefits in terms of time and cost savings for routine QA. Additionally, it allow near real-time machine adjustments, ensuring the SRS system consistently operates within the prescribed specifications.