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Optical surface imaging (OSI) is increasingly used for surface-guided radiotherapy (SGRT), with applications that include patient setup and motion monitoring for brain stereotactic radiosurgery (SRS) and left-breast deep-inspiration breath-hold (DIBH) radiotherapy. AlignRT (Vision RT, Ltd, London) can communicate with a linear accelerator for automatic beam holding using a motion management interface (MMI). Once the MMI is enabled, the AlignRT system becomes inaccessible. This creates a clinical workflow interruption because it is not available during treatment hours to prepare patient data (PData) for future treatments. In our busy cancer center with 20+ AlignRT systems, treatment hours can run as late as midnight. An alternative method is needed to prepare PData to maintain a smooth clinical workflow for future SGRT treatments. Here, we report a new approach to remotely prepare AlignRT PData at any time of day using one of 4 shared AlignRT offline workstations. Once the PData is prepared, Dispatcher, an in-house program, will validate and transfer the PData to any of the 20+ AlignRT online treatment workstations across 8 campuses.

To develop and implement a new clinical workflow that facilitates remote AlignRT PData preparation at any time of day using AlignRT offline workstations and Dispatcher, an in-house Python program, which performs quality assurance checks and transfers PData to AlignRT online treatment workstations for SGRt treatments.

Dispatcher, an in-house python application, allows users to transfer PData to assigned treatment workstations after preparation using the AlignRT application program on one of the 4 offline workstations. These offline workstations are not connected to any treatment machine, and are therefore available at any time. Dispatcher handles dynamic clinical conditions, such as adding transfer capabilities to a new linac, through the use of configuration files. Dispatcher also performs a series of quality assurance (QA) checks prior to dispatch:

- Rejects PData created with unapproved plans, PData with the wrong number of reference images, or wrong couch kicks.
- Checks the treatment history in the destination PData folder, including treatments with multi-sites or multi-machines, and concurrent or existing treatments.
- Creates backup copies in the event of conflicts on the treatment workstations, preventing PData loss.
- Writes a history log file to record all Dispatching tasks in order to track events, clinical workload and statistics.
- Writes a patient-specific log file, including the isocenter coordinates, reference surface labels, and couch angles for QA by the planner and plan checker.

A schematic diagram of the new AlignRT data workflow for SGRT treatment in our clinic is shown in Figure 1. There are 4 offline workstations that have identical functionality. The DICOM receiver of the Eclipse planning system is set to any of the 4 offline workstations. Any local DICOM data is removed by Dispatcher after data preparation to be compliant with US HIPAA regulations. Using the local AlignRT application on one of the offline workstations, the PData is prepared by a planner and saved in a secure network drive, ready to be sent to AlignRT treatment workstations. Once PData is prepared, Dispatcher retrieves the PData from the network drive and dispatches to multiple AlignRT treatment workstations at once in one of the 8 clinical centers within our institution. This allows patients to be treated with AlignRT on multiple machines if the need arises.

Following the TG-100 approach, Dispatcher provides automatic QA checks prior to transferring PData. For example, if a plan used to create PData has not been planning approved, or if the PData of DIBH breast does not contain both DIBH and free-breathing (FB) reference surfaces, or if the PData of an SRS plan has two references, the Dispatcher program will reject the PData and request the planner to check or investigate correctness of the PData preparation. Two dispatching log files are saved: one on the network drive and the other in the patient's electronic folder to allow planner and plan checker to review key data parameters in PData for treatment, including isocenter coordinates, number of reference images, and number of couch rotations (SRS).

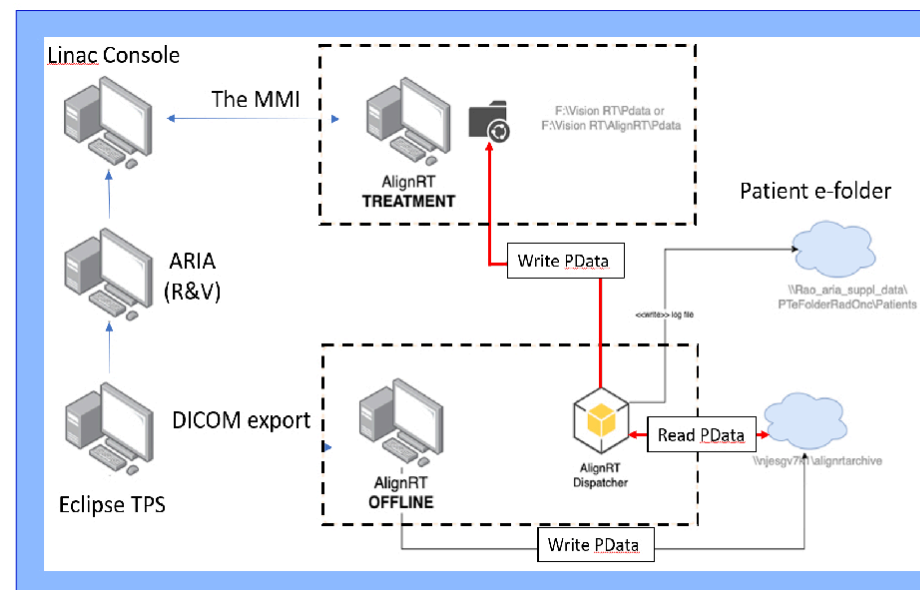


Figure 1. Clinical workflow using four identical AlignRT offline workstations and the Dispatcher program to prepare and dispatch the PData to multiple AlignRT treatment workstations at a clinical center to facilitate any potential machine change during the course of treatment.

In the past 13 months from June 2019 to June 2020, about 3000 AlignRT PData have been prepared, checked, and dispatched using AlignRT offline workstation(s) and the Dispatcher program (Table 1). There are minor version changes from v1.0 to v1.5 as current. The Dispatcher can handle multi-site treatments and concurrent treatments, as it compares the current PData date with the latest PData used on the AlignRT treatment workstation(s). When there is potential conflict of treatment timing, on-going treatment, or different treatment sites, especially for brain SRS/SRT treatments, the user is informed and if they choose to proceed, copies of any previous PData is backed up prior to the new PData replacing it.

Several QA features have been added to the Dispatcher based on major types of clinical incidents that have caused treatment delay. Two examples are (1) a brain SRS that had 2 reference surfaces under one isocenter; a case with treatment couch angles that were split under the two identical surfaces, causing a mismatch when loaded at the machine, and (2) a breast DIBH, in which two identical plans with either FB or DIBH were created and none provide complete treatment information. These events can now be caught by the Dispatcher, which has new QA functionalities, in addition to PData transfer, greatly facilitating the new clinical workflow. At MSK, a Reporting to Improve Safety (RISQ) system is available to allow any clinical staff to report a clinical event that was caught before or during patient treatment, which may or may not cause any treatment delays, problems, or consequences. For instance, in the first half of 2020, there were 17 RISQ events reported. Using this RISQ system, the type of clinical issues or potential issues have been collected and analyzed, resulting in several automatic checking features that have been added in the Dispatcher program to automatically catch these issues before they could reach the treatment floor.

The Dispatcher also creates a patient-specific log file for manual verifications of PData preparation once data has been transferred to the treatment machine(s). The log file includes three key plan parameters: isocenter coordinates, couch rotation angles, and the number reference surface(s). One of these parameters being invalid has caused most clinical issues, including treatment delays. Currently, both planner and plan checker are required to review this file against the plan to check these key elements. This rule is reinforced after one incident where an old plan that was not used due to treatment cancellation was accidentally transferred for treatment due to an incorrect configuration failing for a new user. This would have been caught if the dispatching log file has been checked, due to differences in isocenter coordinates and couch angles.

Compared with the conventional AlignRT PData preparation workflow, the workload is almost the same. However, the new workflow adds a new QA tool to the process (Dispatcher), allows planners to prepare PData remotely for any machine campus wide at any time of their choosing, including during normal working hours.

The use of AlignRT offline workstations combined with the in-house Dispatcher program allows a smooth clinical workflow during regular working hours in a busy clinic where the AlignRT-triggered beam holding is enabled through the MMI interface to communicate with a Linac treatment machine. Over a year of usage with this new workflow has proved that it is clinically sound. With a written clinical procedure, our clinical staff can easily master the new workflow and provide streamlined clinical service, although some occasional minor issues have led to 5 minor version upgrades of Dispatcher over the initial 13 month period. The use of offline workstations for PData preparation, QA and dispatching has proven to be an excellent clinical solution.

Table 1. Summary of clinical implementation of AlignRT offline workstations and Dispatcher program to enhance the clinical workflow. All of the MMI interface of AlignRT-Linac have been enabled after AlignRT system upgrade to version 5.1 under Windows 10 operating system.

	Offline WS-1	Offline WS-2	Offline WS-3	Offline WS-4
Starting Date	6/1/2019	7/1/2019	7/1/2019	10/1/2019
Clinical Use Time (months)	13	12	12	9
Locations	Manhattan	Long Island	S New Jersey	N New Jersey
New Dispatcher Versions since Starting	5	4	4	3
AlignRT-Linac Systems with MMI enabled	7	5	4	5
Frameless Cranial SRS	yes	yes	yes	yes
Breast DIBH	yes	yes	Just started	yes
Total Patient Treatment Prepared	1574	500	357	458

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