Implementation and early clinical success with SGRT in Holy Cross Cancer Center in Kielce

Anna Pawłowska[1], Anna Semaniak[1], Krzysztof Buliński[1,2], Andrzej Dąbrowski[1,2], Rafał Stando[1], Paweł Wołowiec[1,3]

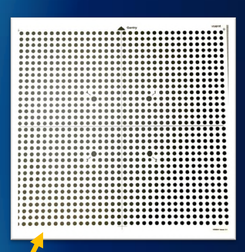
[1]Holy Cross Cancer Center, Artwińskiego Street 3, 25-734 Kielce, Poland, [2]Jan Kochanowski University of Kielce, Żeromskiego Street 5, 25-369 Kielce, [3]Central Office of Measures Elektoralna Street 2, 00-139 Warsaw

Introduction

Four Versa HD (Elekta) medical linear accelerators and one Radixact (Accuray) tomotherapy machine are installed in the Holy Cross Cancer Center in Kielce, Poland. Two of the four accelerators were installed in 2021 (June and September) and are equipped with the Align RT Advance system by Vision RT. Four different treatment planning systems are used: Pinnacle (Philips), Monaco (Elekta), Precision (Accuray), and RayStation (RaySearch).

Surface Guided Radiation Therapy (SGRT) is a technique of irradiation guided by the patient's image. Align RT is a three-dimensional (3D) surface imaging system that allows you to monitor the patient's position in 3D mode before and during radiotherapy. Using patented 3D stereo cameras, AlignRT Advance tracks the patient's skin surface in real-time and compares it to a reference position with an accuracy of less than one millimeter. As a result, radiation is only delivered when the patient is properly positioned, increasing patient safety.

Elements of the Align RT system

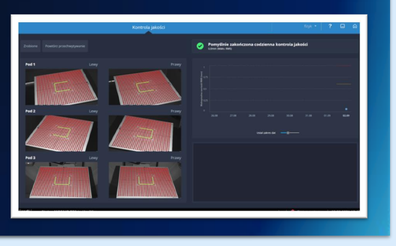


- **3 panels (including 6 3D cameras, 2 cameras in one panel)**
- **calibration tools**
- **advanced software**

Calibration and quality assurance

To ensure the highest quality of performed procedures, the system is calibrated according to the producer's recommendations. Each day, the Align RT cameras are checked for proper positioning against the calibration plate. For this purpose, before the start of the work, daily quality control is performed in which the root mean square (RMS) value is determined. RMS represents the mean divergence between the position of the camera images recorded in the daily quality control with the position of the recorded images during the last calibration of the plate. The maximum allowable RMS value is 1 mm.

Calibration is carried out as the first step in any situation that gives rise to suspicion of system dysfunction. The assumption is to determine the isocenter of the optical surface imaging system.



The therapeutic session with the use of the Align RT system

During each treatment session, the patient's position is compared to a reference surface (the optimal treatment position determined during treatment simulation). The shifts are displayed in the application. This reference surface is generated by importing skin contours from CT volume data generated from a treatment planning system.

In the Holy Cross Cancer Center, to position the patient faster and more accurately, the Align RT application most often uses the following functions: **Patient monitoring in real-time (Surface)**, **Patient positioning (Video)**, **Treatment**, **Send to Couch**, **Beam delay**.

- In addition to being able to compare real-time areas with volumetric data from the treatment planning system in the application, in the Treatment mode, it is possible to use the **position of the patient's body (Video)** function. This mode allows you to use the outline of the patient's reference surface in a live video transmission from three directions (figure below). In this way, technicians arranging the patient have a live view of the most optimal body position and can easily correct the positioning.

- The **Treatment** mode allows you to take pictures of patients, for example, taking a deep breath. The app compares the captured image of the surface with a reference surface, allowing technicians to correct the patient's body position without exposing them to additional inconvenience.
- The Align RT app is compatible with Elekta accelerators. The application has the function **Send to Couch** after application, the application of which adjusts the table position to the most precise positioning of the patient to the reference position.

- Another useful function is **Surface deformation**. Due to this function, changes in the patient's body (e.g. loss of weight or swelling) can be observed. By using the deformation area, it is possible to check whether there are any areas of significant change in the treatment area compared to the reference area. This can help to determine if any further interventions are needed to ensure that the patient is being treated properly according to the treatment plan.

In addition, a **Real Time Couch (RTC)** device is used, which allows you to easily visualize patients irradiated with a deep breath when they are in the most optimal position.

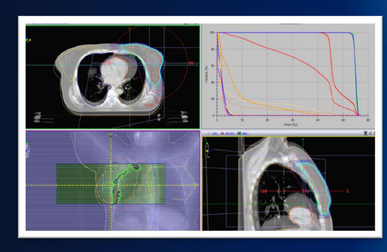
DIBH vs free breathing

At the Holy Cross Cancer Center from September 2021 irradiated 111 patients with left breast cancer using the DIBH technique.

The majority of patients were treated with the VMAT technique. A study was carried out on a group of 35 patients, comparing the volume of the left lung with breath-hold and free breathing. Alternative plans were made for 10 patients with free-breathing.

The results:

- Mean difference in volume for the left lung between DIBH and free breathing: $1232\ cm^3$
- Maximum difference: $1692\ cm^3$
- Minimum difference: $202\ cm^3$



The difference in the volume of the left lung below $500\ cm^3$ causes a reduction of the average heart dose by approx. 0,3 -0,6 Gy (approx. 10%), and above $1000\ cm^3$ - a reduction of the dose by approx. **1,8 Gy** (approx. 45%).

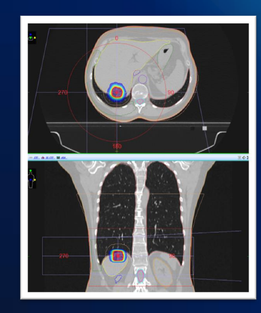
Conclusions:

The study showed that patients for whom the difference in lung volume is less than $500\ cm^3$ does not give a significant therapeutic benefit in the case of irradiation with the DIBH technique. In such cases, it is worth considering the option of traditional therapy to ensure greater comfort for patients during radiotherapy.

Stereotactic Body Radiation Therapy (SBRT)

Since the beginning of the Align RT system application at the Holy Cross Cancer Center, eight metastatic cases were irradiated with SBRT DIBH in locations such as the pancreas, lungs, ribs, and liver. Three examples of SBRT DIBH irradiation under the control of Align RT are presented below.

In the first case, the patient had a neoplastic lesion located in the liver, near the diaphragm. The patient's respiratory movements had a huge impact on the position of the GTV. The patient was irradiated with the breath-hold VMAT technique with 6 MV FFF beams under the control of Align RT. The patient received a dose of 45 Gy in 3 fractions. The reproducibility of the patient's position was verified based on CBCT studies. The margin that would have to be used for GTV for free and breath-hold was estimated. In the case of $GTV_{FREE} = 3\ cm^3$, and $GTV_{DIBH} = 0{,}5\ cm^3$.



Also for the second patient with the lesion in the liver irradiated with SBRT DIBH, a simulation of the change in the margin level for GTV in the case of free and breath hold was also performed. The change in margins was as follows: $GTV_{FREE} = 44{,}5\ cm^3$ and $GTV_{DIBH} = 30{,}4\ cm^3$. In this case, the difference was $14{,}1\ cm^3$.

In both cases, using the DIBH technique under the control of Align RT, the required margin was significantly reduced, and thus the tissue protection was measurable.

In the third case, two neoplastic lesions in the lung were irradiated simultaneously. Before the execution of the treatment plan, the individual mobility degree of each target was assessed. For this reason, it was decided to irradiate each target volume individually (two isocenters) in one treatment session.

The advantage of the above-mentioned method of treatment was to increase the accuracy of the irradiation for the disc volume located above the diaphragm. The mobility towards the superior-inferior was about 2 cm. Thanks to the use of Align RT DIBH, high irradiation precision and very good control of the target volume position in real-time were obtained.

Conclusions:

Thanks to the use of Align RT and RTC, patients were able to recreate the body position on the day of CT simulation, which allowed for the correct irradiation of very moving and difficult to reproduce targets.

References

- J. Wendykier, B. Bekman, A. Grządziel, K. Ślosarek: Radioterapia sterowana obrazem powierzchni pacjenta AlignRT – pierwsze doświadczenia, Inżynier i Fizyk Medyczny, 7 (3), 2018, 203-210
- J.D.P. Hoisak , T. Pawlicki: The Role of Optical Surface Imaging Systems in Radiation Therapy, Semin Radiat Oncol, 28(3), 2018, 185-193
- N. Smith, I. Meir, G. Hale, R. Howe, L. Johnson, P. Edwards, D. Hawkes, M. Bidmead, D. Landau: Real-time 3D surface imaging for patient positioning in radiotherapy, Int J Radiat Oncol Biol Phys, 57, 2003, 187.
- R. Hepp, M. Ammerpohl, C. Morgenstern, L. Nielinger, P. Erichsen, A. Abdallah, R. Galala: Deep inspiration breath-hold (DIBH) radiotherapy in left-sided breast cance, Strahlenther Onkol, 2015
- A. J Hayden, M. Rains, K. Tiver: Deep inspiration breath hold technique reduces heart dose from radiotherapy for left-sided breast cance, Journal of Medical Imaging and Radiation Oncology 56, 2012, 464–472