IAEA Commissioning Expedition of Linear Accelerator

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Abstract

Through using photons and X-Ray light from a linear accelerator to irradiate a Thorax phantom, the commissioning process of external beam treatment machinery play a crucial role in validating the viable operation and behavior of the radiation technique and radiotherapy treatment planning system (RTPS) and process. Commissioning involves the examining testing system functions, authenticating comparing calculated and measured dose calculations, and characterizing various model algorithms.[1] This process must be done to ensure that the radiation machine(s) may be used for clinical treatments.

Background Information

- Commissioning occurs through eight distinct tests, or "cases"
  - which incorporates adjusting and aligning the gantry and collimator of the linear accelerator so the photon beam will irradiate its intended target(s)[2]
- The purpose of each cases is to simulate diverse clinical scenarios that are comprised of singular and multiple beam/field variations
- involves collecting dose measurements from ion chambers wedged into an IMRT Thorax Phantom model 002LFC during irradiation
- measurements obtained from ion chambers during irradiation are then compared to the calculations obtained in the treatment plans confirm the dosage was accurate and the machine functions as designed[3]

Purpose

The commissioning process is lengthy due to the constant readjustment of the ion chamber into the corresponding point(s) of interest for each case. The purpose of this study is quicken the commissioning process by utilizing multiple ion chambers at once for each case, removing the need to move ion chambers and thus reducing the time needed for testing. It is hypothesized that using multiple ion chambers simultaneously would not affect the measured dose calculations.

Methods

1. Licenses and software for needed for PC electrometers were generated and installed respectively onto laptops
2. CT of phantom were imported into Raystation[a]. Each insert of the phantom was individually contoured and labelled as a "regions of interest (ROIs)," with the isocenters labelled as "points of interest (POIs)"
3. Treatment plans were created on Raystation in accordance with [1]. The plans were simulated independently to obtain the calculated dosages, which were used as the reference values of this study
4. Treatment plans were saved and exported to a new linear accelerator to begin irradiation
5. Due to the limited number of usable ion chambers[b], a sequence of ion chamber insertion was developed to acquire maximum efficiency in the commissioning process
6. Measured dosage was procured and validated with reference values of each case to determine dose accuracy and machine functionality

Results

Figure A

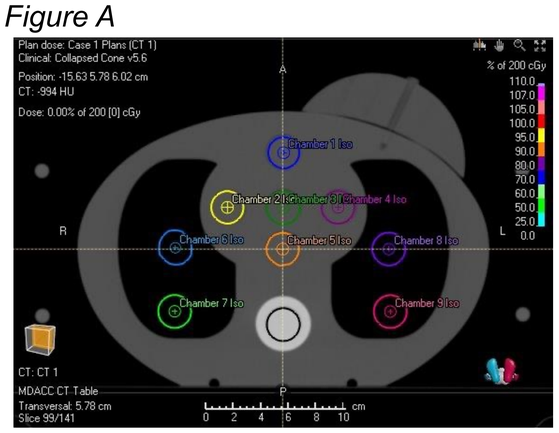

Figure B

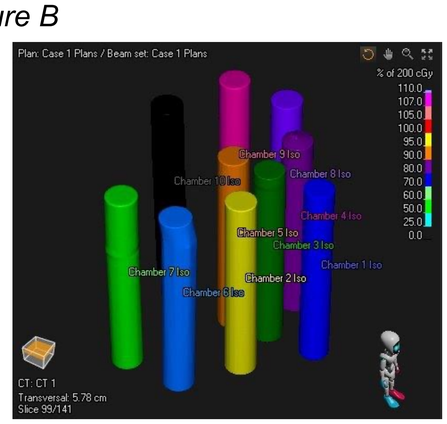

Figure A – 2D CT scan of phantom with each and every phantom insert contoured to highlight the areas of ion chamber insertion
Figure B - 3D contours of ion chamber inserts with corresponding isocenters

Results Cont.

Figure C

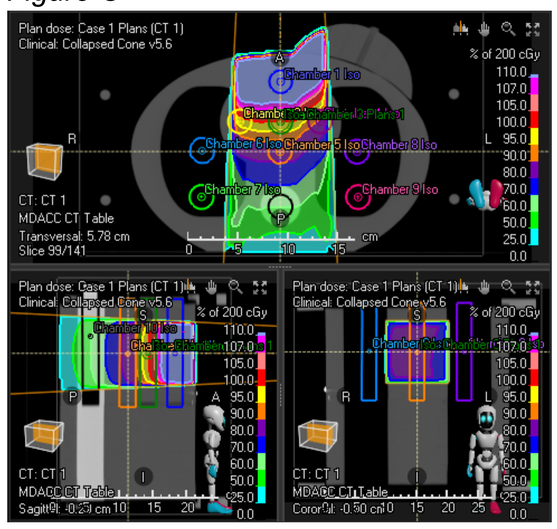

Figure C – Simulation of Case 1 from inferior, right, and anterior viewpoint. Each case is meant to administer 200 cGy of dose to the reference point. In this case, the reference point is chamber 3.

Figure D

Point (i.e. chamber)	Case Plans RayStation Dose [cGy]							
	1	2	3	4	5	6	7	8
1	242	200	244	110	244	19	102	8
2	198	173	198	202	200	18	193	137
3	200	219	200	196	195	200	197	199
4	180	270	180	196	8	25	189	169
5	171	14	170	200	164	89	200	200
6	10	18	16	108	195	16	138	141
7	10	15	18	108	2	12	138	142
8	12	4	22	28	172	111	23	35
9	12	3	26	28	3	4	23	34
10	122	0	120	111	111	174	54	5

Figure D – Calculated dose (reference) values for every case and ion chamber. For each case, the reference point is highlighted in yellow and the measurement points were highlighted in green.

Figure E

Trial #	Case(s)	Isocenter	Ion Chamber Location (s)
1	4, 7, 8	5	1, 5, 6, 10
2	1	3	1, 5, 9, 10
			1, 3, 5, 10
3	2	1	1, 3, 7, 10
	3	3	
4	6	3	2, 3, 7, 10
	5	2	

Figure E – Sequence of trials for expedited commissioning process. This was made with the limited number of ion chambers (4) available for this study.

Conclusion

Based on the simulations performed in Raystation, while the reference point for each case received its prescribed dose of 200 cGy, the other measurement points of interest also received dosage on a much smaller scale. The next step is to export the plans to a linear accelerator and run each case separately, moving the ion chambers according to the sequence developed for maximum efficiency. In this commissioning process, the measured dosage received in the measurement points should match the calculated dosage for all the corresponding cases. This should be done using less time than performing every case with one ion chamber alone.

Discussion

Due to the limitations of this study, the commissioning process could not be performed at its maximum efficiency. The frequent rearrangement of the ion chambers increased the time needed for this procedure. However, the process should be much quicker than only using one ion chamber for each case and measurement point(s). This is important because a quicker commissioning process could possibly correlate to more patients receiving their radiation treatments as more external beam techniques are being clinically tested.

Future Plans

- Carry out commissioning process with linear accelerator and receive dosage measurements
- compare measured and calculated dose using multiple ion chambers
- Calculate percent error for each case and determine acceptance based on predetermined pass-fail system
- Carry out similar procedure with all 10 ion chambers and other necessary equipment

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References

1. International Atomic Energy Agency. Commissioning of Radiotherapy Treatment Planning Systems: Testing for Typical External Beam Treatment Techniques. 2008.
2. International Atomic Energy Agency. Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer. 2004.
3. International Atomic Energy Agency. Specification and Acceptance Testing of Radiotherapy Treatment Planning Systems. 2007.

a. Raystation – RTPS software used for contouring scans, simulating plans, and evaluating dosage
b. Four ion chambers posed as a limitation of this study, so they must be rearranged frequently, thus slightly increasing the time for commissioning