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Evaluation of IMRT patient specific quality assurance with ion chambers of different active volumes

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Abstract

Objectives: IMRT is a novel technique in radiotherapy. Our aim is to compare the point dosimetry in treatment planning system and on actual phantom with different volume chambers in IMRT QA.
Methods/Statistical analysis: 18 patient plans of IMRT with different lesions were selected for this work. Ionization chambers with 0.6 cc , 0.13 cc and IMRT slab phantom were used. Both the chambers were calibrated in national standard laboratory. Treatment machine calibration was verified before doing this dosimetry. Electrometer stability is also verified for the good results. QA plans were exported to linear accelerator after the TPS measurements. All the results were compared.
Findings: The maximum variation observed between the chambers in measured data is 3.51 % where as in TPS this is 2.2 % only which is within acceptable limit. Also, it is observed that, 0.13 cc chamber showed less deviation in few cases where dose gradient is more in the plan. With the advancements in the equipment and technology, varieties of ionization chambers with different sensitive volumes are currently available in the market. Also, intensity modulated radiotherapy practice has been increasing constantly due to its proved results. It is very important for a physicist to select a suitable chamber for doing patient specific QA. Hence, this type of study will help for practicing physicists/dosimetrists.
Application/Improvements: This study can be extended with more number of sensitive volume chambers from different vendors.
Keywords: IMRT, ionization chamber, QA, Linear accelerator

1. Introduction

Development of multi leaf collimator based linear accelerators changed the cancer therapy treatment scenario. Intensity modulated Radiotherapy (IMRT), where the complex dose distributions will be formed using powerful treatment planning systems (TPS) with non uniform photon fluence is a very widely used technique in current radiotherapy practice. Because of the most critical beam modulation, each IMRT field may consist of many small and irregular beam lets which forms combined conformal dose distribution to the target. Steep dose gradients will be different, for different cancer lesions. These qualities of IMRT impose the necessity for the dosimetric verification with suitable instruments [1-6] before implementation.

Verification of photon fluence before dose delivery is the effective and safe method to ensure the qualitative treatment. This can be done using ionization chambers, films, array detectors [7] etc., Ionization chambers play a very important role in the dosimetry of Radiotherapy. They are considered as the gold standard for dosimetry because of the precession, easy to use and free availability [8]. This instrument is frequently used to measure the absorbed dose to water and photon fluence verification using slab phantoms in hospitals. A well calibrated chamber from standard laboratory must show linear response for wide range of irradiated radiation doses.

Currently, many verities of ionization chambers are available with different active volumes. Though, all are used for point dose measurement only, there may be a variation in the measured dose due to the difference in

sensitive volume. Hence, our objective was to compare the dose measurements with different sensitive volume ionization chambers available with us, using different IMRT cases.

2. Materials & methods

The calibrated ionization chambers with 0.6 cc , 0.13 cc (IBA, Sweden) and IMRT bench mark slab phantom (Med Tek, USA) were using in this study. This 3D phantom is constructed with virtual water and is compatible with different ranges of ion chambers and other detectors. The slab phantom with the insertion of chamber at 10 cm depth from the top surface of the phantom is scanned in our CT simulator with the selection of 3 mm slice thickness. This phantom data is transferred to the XIO planning system (version, 4.33.02; Computerized Medical Systems, St. Louis, USA). The volumes of the chambers drew in CT slices were exactly reflecting the original sensitive volume quoted by the manufacturer. 18 cases treated with IMRT technique using synergy linear accelerator (Elekta Oncology Systems Ltd, Crawley, UK) with 80 leaves MLC were used in this study. The selected IMRT cases include different sites such as head/neck, breast, cervix, prostate etc.,

The active volume of each chamber was contoured on CT slices to create point of interest. The IMRT plan is posted on this phantom to create patient specific quality assurance verification plan. The average dose generated by the planning system in active chamber volume is noted for both chambers. The same plans were transferred and executed by setting the phantom under linear accelerator. The machine calibration was verified before using for IMRT dosimetry. The cumulative reading shown by the electrometer in each case was recorded. Then, this was converted as absorbed dose using TRS 398 method [9]. This measured data was compared with the planning system data in each case and with both chambers. All the instrument settings were cross checked by two physicists for accurate dosimetry. The results were tabulated as shown.

3. Results & discussions

TPS measurements

Table 1 shows the plan dose compared between 0.6 cc and 0.13 cc in TPS for all the cases. The mean variation between two chambers in TPS is 0.43%; the maximum variation is 2.2%. The standard deviation is 0.61.

Table 1. Measured dose comparison between two chambers

S.no	Measured dose in cGy (0.6cc)	Measured dose in cGy (0.13cc)
1	170.5	167
2	181	180
3	123.5	121
4	139	138.5
5	167	165
6	297	297
7	120	119.7
8	169	167.8
9	92	91.5
10	162	160.8
11	112.7	112.03
12	145.3	144.8
13	167.9	165.9
14	131.1	127.7
15	100.6	99.4
16	144.1	143.7
17	190.18	183.5
18	162	162.3

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Phantom measurements

Table 2. Plan dose comparison between 0.6 cc and 0.13 cc in TPS

S.No	TPS dose in cGy (0.6CC)	TPS dose in cGy (0.13CC)
1	165	165
2	178	178
3	121	120
4	137	138
5	165	163
6	295	294
7	118	118
8	165	165
9	90	92
10	160	160
11	111	111
12	142	142
13	166	166
14	127	127
15	99	98
16	141	140
17	183	183
18	163	164

Table 2 indicates the actual measured dose comparison between two chambers. The mean variation between two chambers is 1.02 % and the maximum variation is 3.51%. The standard deviation is 0.95. Figure 1 shows the comparison between TPS and measured dose with 0.6 cc chamber. The mean variation is 1.91 % and the maximum variation is 3.92%. The standard deviation is 0.87. Similarly Figure 2 indicates comparison between TPS and measured dose with 0.13 cc chamber. The mean variation is 1.05 % and the maximum variation is 2.64%. The standard deviation is 0.65. After the careful observation of the above data, it is clear that the difference between the measured values for both the chambers in TPS as well as actual phantom measurements is less than 5 % in all types of comparison which is very much acceptable. The maximum variation observed between the chambers is 3.51 % only (Table 1) where as in TPS this is 2.2 % (Table 2). Hence, both chambers are suitable for IMRT patient specific quality assurance. Though, both chambers showed similar results, it is observed that, few cases where dose gradient is more complex, 0.13 cc chamber showed less variation compared with 0.6 cc. This is clearly due to the variation in the sensitive chamber volumes.

Figure 1. Comparison between TPS and measured dose with 0.6 cc chamber

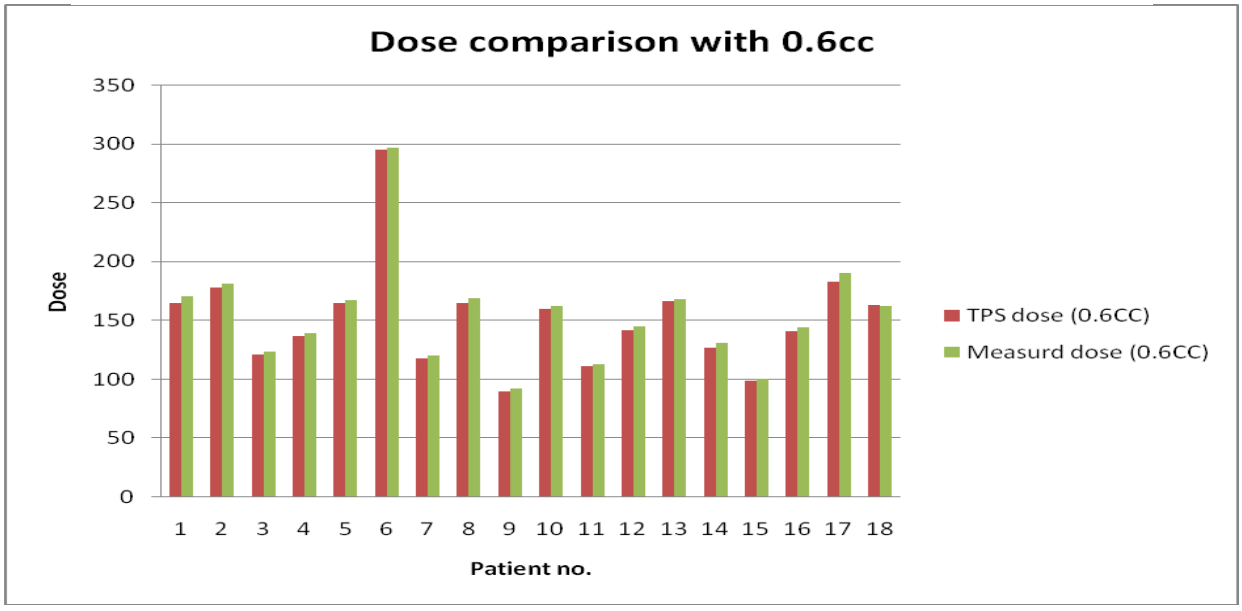

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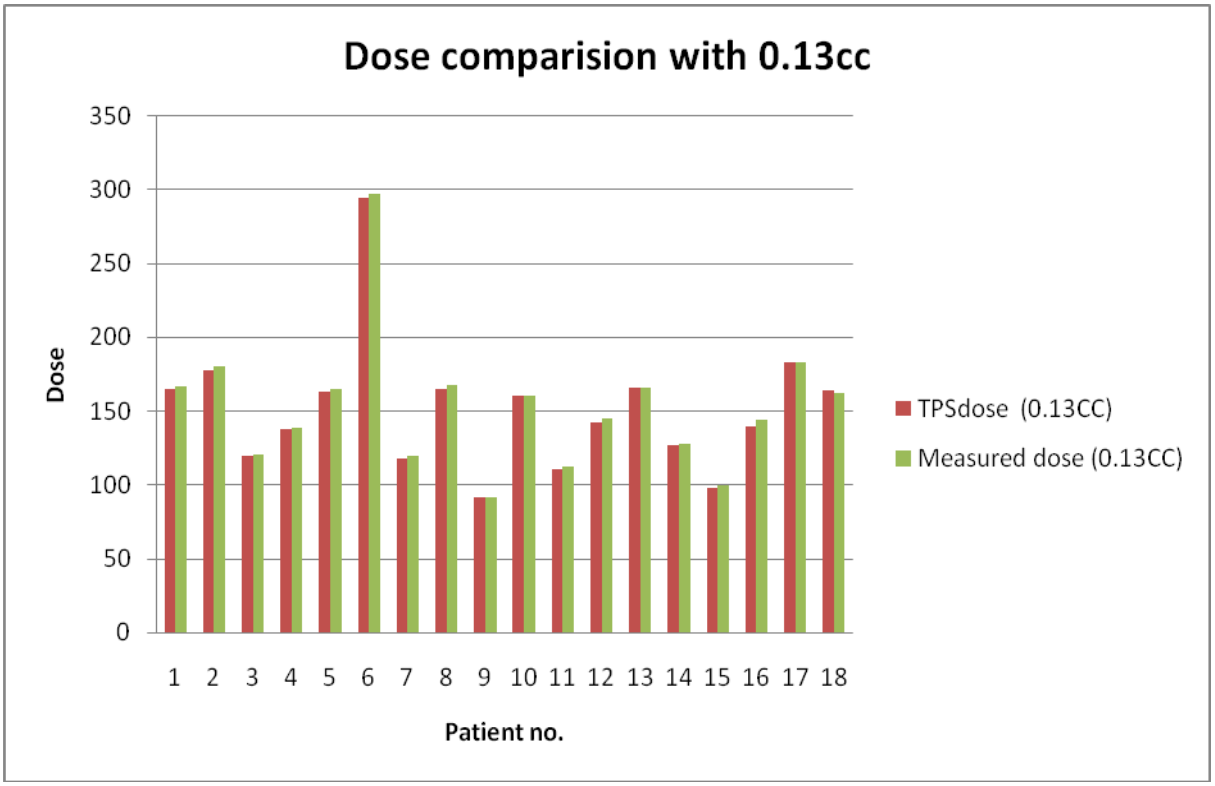
Figure 2. Comparison between TPS and measured dose with 0.13 cc chamber



4. Conclusions

From this dosimetric study, we conclude that, both 0.6 cc and 0.13 cc chambers are suitable for routine IMRT patient specific QA purpose. But, it is recommended to use less volume chamber if the case consists of complex dose gradient in the distribution.

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