Comparison between different Dosimetric Tools based on Intensity-modulated Radiotherapy (IMRT): A Phantom Study

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Abstract

This study examined the gamma passing rate (GPR) consistency during applying different kinds of gamma analyses and dosimeters to IMRT. **Methods:** Import treatment protocols for QA phantom irradiation have been recalculated. A gamma analysis was used for comparing the measured and calculated dose distribution of IMRT for different gamma criteria (2%/2mm, 3%/3mm, 4%/4mm, 3%/5mm, 3%/5mm). These criteria are evaluated when 5%, 10%, or 15% of the dose distribution is suppressed. Measured and calculated dose distribution was evaluated with gamma analysis to dose difference (DD) with DTA criteria (distance to agreement). IMRT QA plans to 25 patients from various sites were formed with the Varian Eclipse treatment planning system. **Results:** Results indicate different diverse hardware and software combinations show varied levels of agreement with expected analysis for the same pass-rate criterion. For a dosimetry audit of the IMRT technique, an EPID detector is superior to conventional methods comparable to Gafchromic EPT3 film and 2D array due to cost, time-consuming, and set up error to get result analysis. The gamma passing rate (GPR) average is increased by increasing the low-dose threshold for different dosimetric tools. For EPID, regardless of the gamma criterion employed, the %GP does not appear to be dependent on the low-dose threshold values (5%-15%) because it indicates that fulfilment the low-dose threshold to global normalization has little effect on patient-specific QA outcomes. **Conclusions:** It is concluded that GPRs differ depending on gamma, dosimetric tools, and the suppressing dose ratio. To get the best results of quality assurance, each institution should thus carefully develop its procedure for gamma analysis by defining the gamma index analysis and gamma criterion using its dosimetric tools.

Key Words: IMRT Verification, Gamma Analysis, Low Dose Threshold, Gafchromic Film Dosimetry, 2D Detector Array, Portal Dosimetry.

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Introduction

Radiotherapy is among the essential therapy modalities in the cancer management(Abi Jaoude et al., 2020). The radiation therapy process has been advanced from two-dimensional radiotherapy (2D) and three-dimensional conformal radiotherapy (3D-CRT) to intensity-modulated radiotherapy (IMRT), and volumetric modulated arc therapy (VMAT). Highly conformal radiation curing including intensity-modulated photon fields have progressively been implant recently. The purpose of these techniques is to accomplish dose distributions of elevated accordance to the target volumes, but extra decreasing the doses to non-target organs at risk.

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The ability to increase the tumor dose while minimizing side effects on these organs is essential for achieving the best possible tumor control. (Zhang et al., 2010) Usually this can exclusively be fulfilment via elevation the dose inhomogeneity. Like distributions of dose can be formed using dynamic techniques (DMLC), segmental techniques (SMLC, or step-and-shoot) and the implantation of absorbers. Due to these techniques give highly modulated dose profiles, considerable concern should be taken to certain their proper implantation. Together with enhanced patient immobilization precision, many machine-and system-dependent parameters should be analysed with cautiously adjusted before starter IMRT (Otto, 2008). IMRT utilizes a multi-leaf collimator (MLC) for varying the beam intensity provided to the tumours, being a process, which includes the delivery of complex intensity manner from different gantry angles.

Because of the complication of the remedy plans, the typical care is to achieve a measurement-based, patient-specific, quality assurance QA. The quantitative comparative for the planar dose distribution with the gamma index is a popular method for assessing the agreement between the measured dose and the calculated. The American Association of Physicists in Medicine (AAPM) Task Group (TG) 119 specified the following criteria for acceptance: 3 % dose difference (%DD) for per-field analysis, and a global normalizing technique, a 3 mm distance-to-agreement DTA. Additionally, 90% gamma rate (% GP) action level is used to reduce background noise at a dose threshold of 10 % (Ezzell et al., 2009).The main tasks of the IMRT quality assurance include the provision of the plan of IMRT into a phantom and a comparison of the 2D dose distribution measured by treatment planning system and a dose calculated by Gafchromic EBT_3 film, a 2D array ionisation chamber, and EPID(Chang et al., 2020; Ibrahim, Mohamed, & Zidan, 2018; isa khan & Zahoor, 2019; Mohamed, Ibrahim, Zidan, El-Bahkiry, & El-sahragti, 2018).The choice of a specific combination of gamma evaluation and acceptance criteria must be dependent on the precision and capacity to detect problem areas in the expected dose distribution of the measuring procedures, in addition to combinations between gamma evaluation and approval criteria depending on several variables, including the dosimetric device, the measuring grid, and the data analysis software. Hence, provision of specific guidelines applicable for all cases is very difficult (Mijheer B, 2008). In view of this circumstance, this paper aims to investigate the compatibility of IMRT dose calculations at different sites of TPS tumors in LINAC at the National cancer Institute, Cairo, Egypt. Several tests were performed using different dosimetric tools (Gafchromic EBT_3 films, a 2D array ionisation chamber, and EPID to showing 2D graphics of dose measurements, that will allow for the development of a procedure for presenting a full process QA, evaluating the usability of methods deployed, and recommending the usage of quicker and highly effective dosimetric instruments of IMRT dose conformation.

Material and Methods

1. Treatment Planning

Computed tomography (CT) images of 25 different tumour sites (head &neck, lung, prostate, and rectum), each being 3 mm thick. Organs at risk (OARS) and gross tumour volume (GVT), planning target volume (PTV), clinical target volume (CTV) were defined and contoured using radiation oncologist. The CT simulator is General Electric (GE LightSpeed VCT 64 CT scanner). The images were then forwarded to the planning system (TPS) Varian Eclipse and for each patient an IMRT plan was created. A Varian type linear accelerator treatment planning system Ver. 13.7 (Varian Medical Systems) installed at National Cancer Institute, Cairo, Egypt was deployed using 6 MV of energy. For calculation, an analytical anisotropic algorithm (AAA) was employed. Under these conditions, with the gantry, couch, and collimator positions set at 0^o, then the QA plans created. All dosimeters were calibrated depending on manufacturer's specifications to provide correct dose distribution. The outputs of the LINAC were calibrated according to the American Association of Physicists in Medicine task group 51 for measuring the 2D dose distributions (Almond et al., 1999).

2. QA Tools

- *Verisoft*

The Verisoft (PTW-Freiburg, Germany) software program was utilized for calculating the 2D gamma values to compare 25 patients. The Verisoft software program allows comparison of dose distributions measured using some dosimetric systems then computed via radiotherapy treatment planning systems. The software for gamma evaluation method aids in locating cold and hot

spots, whilst also determining the maximum and average deviation in both calculated and measured plan (Hussein, Clark, & Nisbet, 2017). 2D gamma measurements were made using the conventional gamma concept by Low et al. (1998). To calculate the global gamma rate, the dose difference relative to the maximum doses was calculated. Figure 1 shows the concept of gamma verification.

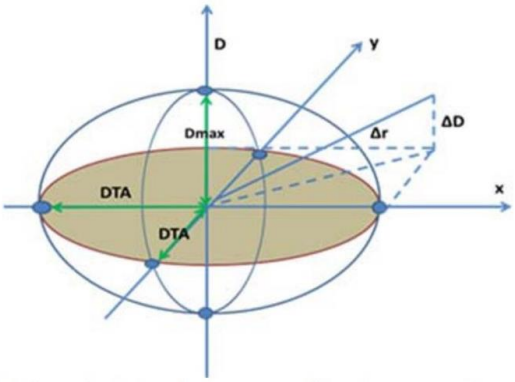

Figure 1. The gamma verification principle: x, y, D positions and dose dimension; DTA (distance to agreement), ΔD max (Max. dose deviation), Δr, ΔD local position and dose divergence of analysed point

- *Gafchromic EBT_3 film*

EPT3 is among the dosimetry devices utilized for patient plans quality control. Gafchromic EBT_3 is intended to measurement of absorbed doses of ionizing radiation, which is especially appropriate to high-energy photons and dynamic range for this film is developed for best execution in the dose range between 0.2-20 Gy making it appropriate to many implantations such VMAT, IMRT and brachytherapy. Figure 2 illustrates the composition of the Gafchromic EBT_3 film (Micke et al., 2015) (Borca et al., 2013). The conventional process of QA for IMRT is 2-dimensional testing utilizing film. Commercial Gafchromic EBT_3 film was used and an Epson Expression 11000-XL flatbed film scanner.

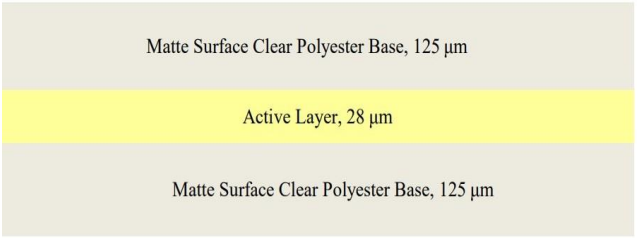

Figure 2. Structure of Gafchromic EBT_3 film dosimetry

The films were exposed in a phantom consist of 30 × 30 cm^2 sheets of solid water. The calibration curve illustrates the association between the film's optical density and the absorbed dose. For calibration curve determination, the calibrated films were irradiated with 6 MV photon beam energy and ten separate dose levels were applied for a 10x10 cm^2 field scale, with one field per film, thus resulting in ten film slides. There was also one single slide of non-exposed film for evaluating the base and fog the OD. The films were placed on the central axis of the beam below 5 cm polystyrene and below the film was 10 cm of polystyrene.

In the phantom under the film plane, a PTW TM30013 calibrated ion chamber (PTW, Freiburg) was added to monitor the LINAC output throughout the process of irradiation and to detect the dose given for the film the IAEA-TRS 398 protocol was applied (Huq, 2006). Calibration curves between optical density and absorbed dose were formed as illustrated in Figure 3.

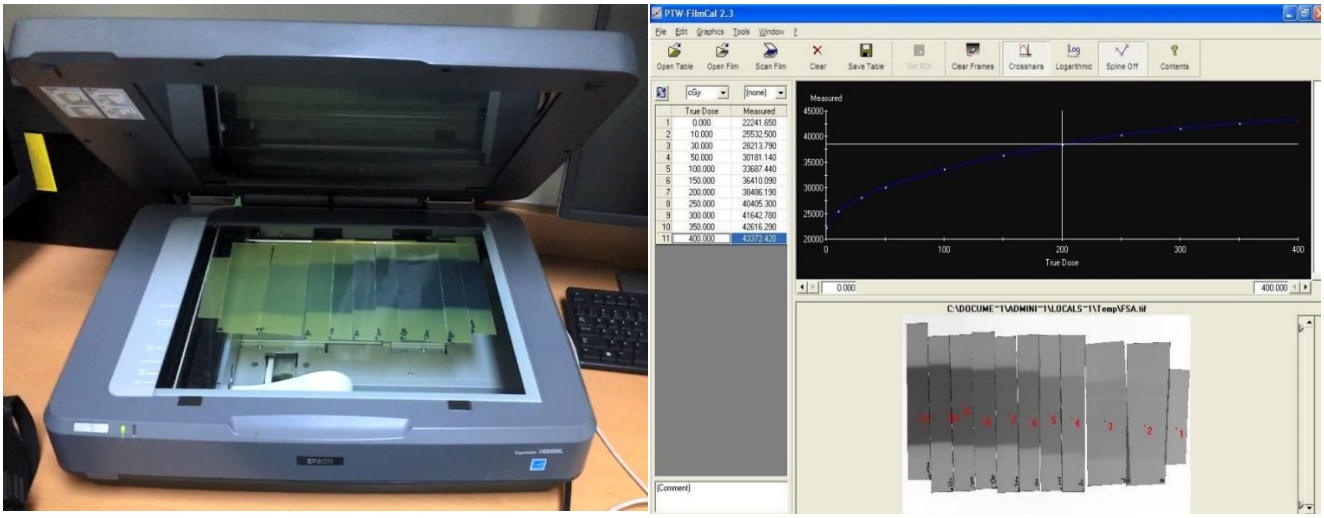

Figure 3. Left, film scanning; right, curve of film calibration created by films irradiated in various doses

- *2D Array Ionisation Chamber*

The 2D array comprises 729 air-vented cubic ionisation chambers consistently organized in a 27 x 27 matrix with an active area of 27 cm^2. The detector spacing (centre to centre) is 1 cm and the dimensions of each detector are 0.5 × 0.5 × 0.5 cm^3, with the 2D array being worked at a chamber voltage of 400 V. The reference point of the detector is situated at 0.5 cm behind the 2D array surface. The guard material is graphite and the material encompassing the vented ionisation chamber is polymethyl methacrylate. The estimation ranges for the total dose are 200 mGy to 1,000 Gy whilst the dose rate estimations range from 500 mGy/min to 10 Gy/min as recommended by the producer (Thwaites 2003).

To represent the build-up and backscatter, the 2D array ion chamber arrangement is sandwiched between a virtual water phantom. The effective point of estimation of the 2D array was kept at 5 cm depth from the surface of the virtual water phantom and the source-to-surface distance (SSD) at 95 cm. Figure 4 illustrates the 2D array ionisation setup. The detector is placed such that the central axis of the beam goes through the central ion chamber.

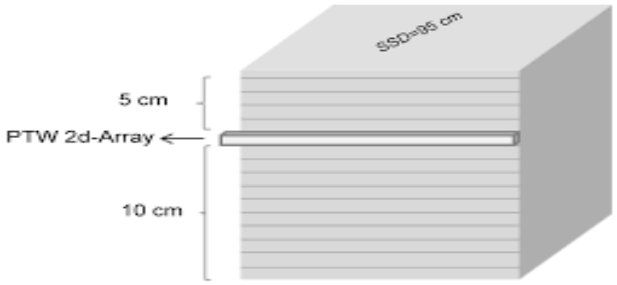

Figure 4. 2D array ionisation setup

- *EPID QA: Portal Dosimetry*

The Portal Vision a Si1000 Varian Clinic image board was utilized, with a pixel measurement and spatial resolution of 1024 × 768 and 0.392 mm per pixel, separately. It is helpful apparatus in the QA process with excellent evaluation capabilities, all information was obtained at a similar SID of 140 cm, utilized throughout the absolute calibration of the imager (Medical Systems of Varian) Portal Vision Exact-Arm The linear accelerator contains an aS1000 Portal Vision imager included primary plate with a thickness of 8 mm, a thin copper slice (1 mm) and a 0.5 mm phosphor film. During the 'verification plan' conveyance on the LINAC, integrated images were obtained with the calibrated EPID.

QA was completed on all the LINACs to guarantee consistency in output, flatness, and symmetry. Calibration of EPID was done by the seller recommendations, absolute dose calibration, flood field, and dark field. With 100 Monitor Units (MU) and a 10 x 10 cm^2 open field, the calibration was carried out as a result of the EPID response, 1 CU corresponded to 1 MU delivered.

- *Gamma Evaluation and Measurement*

Three types of dosimeters were used for the analysis of gamma index for each IMRT plan. For each condition, irradiations were measured using Gafchromic EBT_3 film, a 2D array ionisation chamber and EPID. TPS calculated doses had been compared with the measuring doses using three dosimetric tools based on the gamma evaluation (2%/2mm, 3%/3mm, 4%/4mm, 5%/5mm, and 3%/5mm). The gamma approach evaluates the dosimetric or spatial disagreement, measuring the nearest distance of each reference point, then assessed dose distribution after scaling using the dose differential and distance-to-agreement criteria.

Table 1 illustrates the general passing rate of IMRT QA rates based on the dosimetric tools. To assess dependence of QA on the tools, for the same patient IMRT QA multiple dosimetric tools should be utilized. The average passing rates for each patient using a different dosimetric tool can be noticed in Table 1 based on the gamma index method.

Results

Due to the complexity of IMRT therapy, it should be evaluated before patients are treated, if the treatment is provided as planned by a linear accelerator. To achieve this, the precision and applicability of the dosimetric control techniques utilized were investigated. The results gained for all the gamma criteria were compared. That was, comparisons were made between the five gamma criteria for 25 different tumour patients. To explain the dependence of the QA results on the dosimetric instruments, the IMRT QA of the same patient and the same gamma criteria with different dosimetric tools should be performed. The results obtained are provided below in Table 1.

Table 1. The average and standard deviation values(ss) for all gamma criteria and different suppressing dose values of 25 patients based on different dosimetric tools

Gamma criteria and suppressing dose (cGy) below	Gafchromic film EBT_3 (average and SD)	2D array ionisation chamber (average and SD)	EPID (average and SD)
(2%/2mm)			
5%	85.1±4.4	86.1±3.2	94.24±3
10%	90.6±4.1	92.3±3	94.17±3.1
15%	92.2±3.2	93.3±2.9	94.05±3.3
(3%/3mm)			
5%	86.3±3.3	87.4±3	95.3±2.9
10%	91.3±3.2	93.5±2.8	95.28 ±2.7
15%	93.3±3.2	94.2±2.7	95.01±3.2
(4%/4mm)			
5%	87.5±3.3	90.5±2.9	96.41±2.7
10%	92.5±3.1	94.3±2.6	96.36±2.9
15%	94.3±3	95.2±2.5	95.98±3.1
(5%/5mm)			
5%	90.8±3.2	92.2±2.8	98.7±2.4
10%	95.3±3	96.6±2.5	98.5±2.1
15%	96.3±2.9	97.4±2.5	98.23±2.9
(3%/5mm)			
5%	89.4±3.2	91.4±3	97.3±2.8
10%	94.6±3.1	95.6±2.7	97.2±2.9
15%	95.6±3.1	96.8±2.6	96.82±3.1

1. Measurements Using Gafchromic EBT_3 Films

Table 1 reveals the average gamma passing rate and St. D (standard deviation) for several gamma criteria and different suppressing dose ratios (5%, 10%, 15%) by using Gafchromic EPT3 film. 25 patients with malignant tumours were compared to determine which criteria should be applied (2% 2mm, 3% /3mm, 4% /4mm, 3% /5mm, 5% 5mm) DD/DTA. A comparison between measured and calculated doses was then made in TPS. The criteria of 3%/3 mm show gamma passed % greater than 90 % when suppressing the dose below 10% and 15%, but less than < 90% at 5%. All the data reveals the highest gamma passed the percentage values (gamma passed % > 90%) when suppression the dose under 15% for all gamma criteria (2% 2mm, 3% /3mm, 4% /4mm, 3% /5mm, 5% 5mm). When analysing the comparisons of gamma values calculated in TPS and measured using Gafchromic EBT_3 film, below the gamma analyse criteria of 4% DD and 4 mm DTA, the averages were found 87.5, 92.5, and 94.3 for suppressing doses below 5%,10%, and 15% respectively, this agreement (Nalbant, Kesen, & Hatice, 2014). The data of 5%/5mm reveals acceptance of gamma passing of dose distribution using Gafchromic film regardless of the different suppressing dose ratios (5%, 10%, 15%), which indicates more stability. The standard deviation and gamma passing rates derived via comparison the TPS results and total IMRT plan measured by Gafchromic EBT_3 film in a PTW RW3 solid water phantom of various gamma criteria when suppressing the dose under 15%.

2. Dose Measurements Using a 2D-array

To assess the efficiency of various dosimetric tools (Gafchromic EBT_3 film, 2D array, and EPID), the same gamma criteria utilized in the measurements of Gafchromic EBT_3 were applied to 25 patients' 2D ionisation chambers. The criterion (3%/3mm) shows gamma passed % < 95% for all suppressing dose ratios. The results show that the value measured in the IMRT plans corresponds closely to that estimated using the TPS for gamma criteria (5%/5mm) and (3%/5mm) for both suppressing dose ratios (15%, 10%). Al the results of dose distribution comparison between computed and measured using a 2D-array ionisation chamber were 90% to 100% of all gamma criteria which are used in the study excluded suppressing dose below 5%. The averages of the results from gamma analysis gained from the comparative the TPS with the measurement of the PTW 2D array for (2%/2mm) gamma criteria, were 86.1, 92.3, and 93.3 for different suppression of the dose below ratios of 5%, 10% a 15% respectively. Figure 5 shows the standard deviation and gamma passing rates derived via comparison the TPS results and total IMRT plan measured by a 2D array ionisation chamber in a PTW RW3 solid water phantom of various gamma criteria when suppression the dose under 15%. In the PTW 2D-Array seven29, for the 3%DD and 3 mm DTA criteria, the gamma analyses ranged from 91.4% to 100%. The results were found to be between 87.7% and 95.5% in the TPS-film dose fluence map comparison (Llinares, Fernández, Pain, Caballero, & Oquendo, 2012).

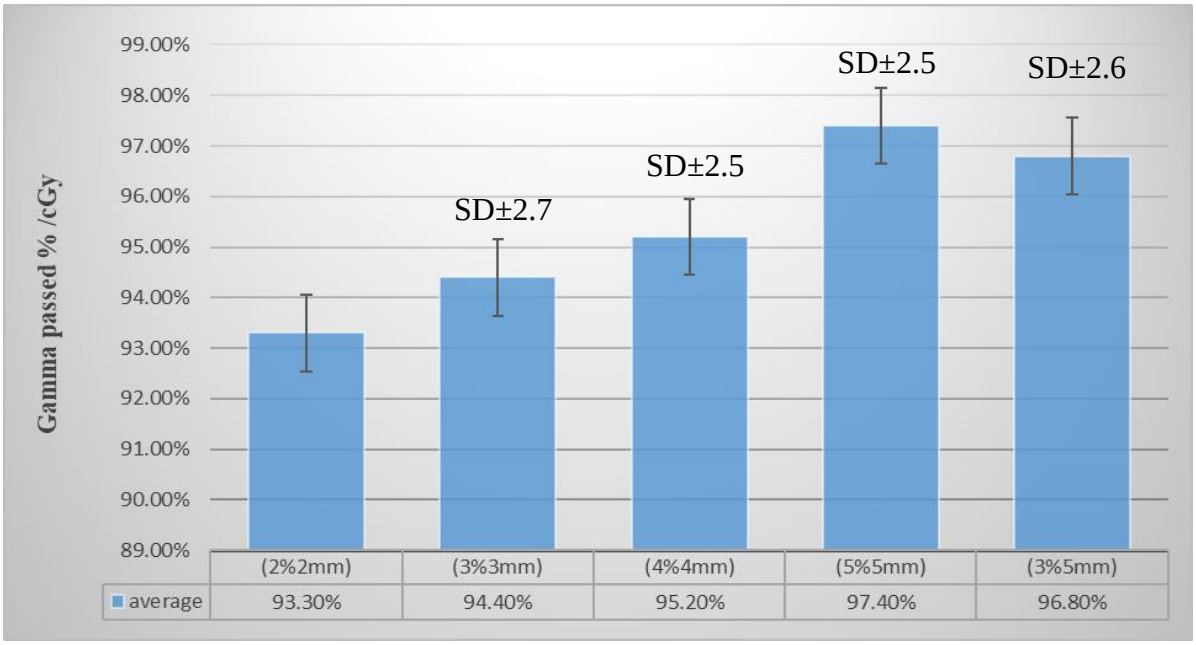

Figure 5. The standard and gamma passing rate derived by comparing the TPS results with total IMRT plans calculated via a 2D array ionisation chamber in a PTW RW3 solid water phantom of different gamma criteria when suppressing the dose below 15%

3. Dose Measurements Using EPID

The same scenarios of gamma criteria with 25 patients were utilized in two previous dosimetric tools applied by using EPID for comparing the effectiveness of the various dosimetric tools. For each of the 25 patients, the average and standard percent deviation GP was computed for all the acceptance criteria, as shown in Table 1. For all gamma criteria reveal that gamma passed greater than 90% regardless of any dose suppressing ratio of a threshold below. As the low-dose threshold elevates from 5% to 15% to all gamma criteria. Figure 6 shows the standard deviation and gamma passing rates derived via comparison the TPS results and total IMRT plan measured by an EPID of different gamma criteria when suppressing the dose of 15%.

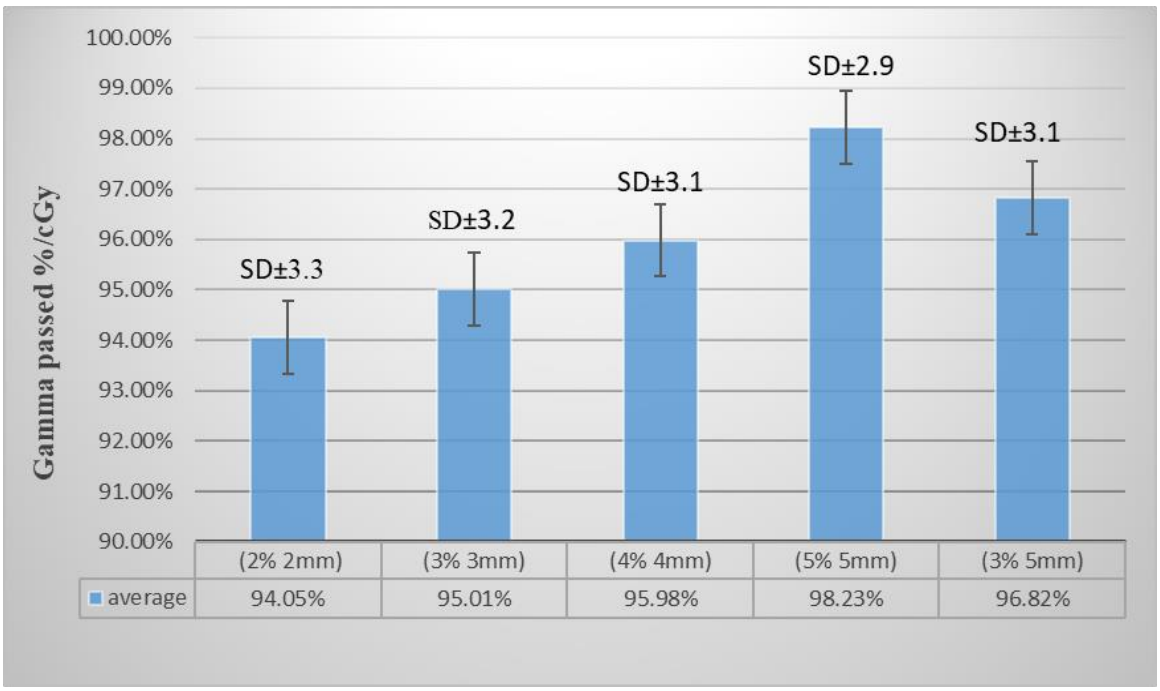

Figure 6. The stranded deviation and gamma passing rates delivered by comparing the TPS results with total IMRT plans measured by EPID of different gamma criteria when suppressing the dose below 15%

Discussion

Before radiation treatments, IMRT needs QA for each patient, however, there is no golden rule to approve of the checking procedure (Wilcox et al., 2008). IMRT-plan quality assurance can be carried out in a variety of different methods. As of yet, there are no inter-institutional standards for quality assurance of IMRT plans (Nelms & Simon, 2007). Ideally, a QA independent from TPS is used to verify the patient specific IMRT plan before treatment. However, the EPID system, postprocessing algorithm portal, portal image acquisition and dose prediction algorithm utilized in this investigation are all from the same vendor (Varian Medical Systems). As a consequence, before being used in clinical settings, the implantation of this portal dosimetry device was independently verified utilizing the 2D ion chamber array. Furthermore, gamma analysis data from clinical IMRT plans calculated utilizing a 2D array or Gafchromic EPT3 film with portal dosimetry are accessible separately, no data comparing 2D array or Gafchromic EPT3 film with portal dosimetry findings in a significant numeral of clinically planned IMRT is available to our knowledge. The dosimetric results for three methods was evaluated in our study, which covered the most complex and prevalent clinical sites treated using IMRT. The global gamma passage rates with different gamma criteria of the IMRT plans for different remedy sites, measured using Gafchromic EBT_3 film, a 2D array ionisation chamber, and EPID dosimeters are shown in Figure 7. The Low et al. Gamma Index is a dimensionless measure that includes both DD and DTA. AAPM TG 119 recommends 90% DD/DTA for 3/3 mm and the research of the ESTRO recommended a criterion of 4%/3 mm with 95% passing criteria (Mijheer B, 2008) (Ezzell et al., 2009). A lot of guide reports proposed various DD/DTA parameter criteria (Isa Khan & Zahoor, 2019) (Wilcox et al., 2008). However, till now the gamma passing rate recommendations and reporting have been limited, these criteria still experimentally defined (Atiq et al., 2017). International Commission of Radiation Units and Measurements ICRU suggests a 5%/5 mm criterion for less strict γ score (Grégoire & Mackie, 2011). There is no widespread agreement, though. Previous research suggests that a positioning error for the multileaf collimator, insufficient dosimetric data of the MLC in complication of the tumour site, the treatment planning system, delivery mode, as well as user mishandling of the dosimeter could all contribute to dose difference measurement discrepancy (Jang, Liu, & Mohan, 2008) (Low, Moran, Dempsey, Dong, & Oldham, 2011). also Depending on how the QA process is carried out, it may result in mistakes and he device-induced uncertainty is predicted to be 1.5%, whereas the total standard uncertainty of the measured IMRT dose is around 2.3% (Fenog lietto et al. 2011). The variation in results was attributable to the fact of this study utilized more lenient gamma criteria of (4% 4mm, 3% 5mm 5% 5mm) instead of the stricter criteria of 3% /3 mm used in AAPM TG 119, also According to previous research, positioning error of multileaf collimator (MLC), Dosimetric data of MLC in the treatment planning system is insufficient, delivery mode, tumour site complication, This might be due to user error when it comes to handling the dosimeter (Ezzell et al., 2009), (Atiq et al., 2017), (Maraghechi et al., 2018). For Gafchromic EBT_3 Films note increasing the gamma passing rate with increasing gamma criteria and suppressing dose below ratio due to The low dose usually happens on the penumbra or the periphery of the target (Ezzell et al., 2009). Film dosimetry is an established and conventional approach to verifying high spatial resolution two-dimensional IMRT dose distributions. The sensitivity of the film depends on photon energy and dose rate and the dosimeters of the film require strict processing requirements (Martens, Claeys, De Wagter, & De Neve, 2002). Nalbant et al., when comparing film dosimetry to a 2D array for IMRT plan verification, the latter showed that the analysis can be performed without any time-efficient, additional scanning or calibration processes (Nalbant et al., 2014). Spezi et al. the repetitiveness of PTW 2D-ARRAY seven 29 were excellent even to short, medium, and long-term measurements in open areas ranging from 2x2 cm^2 to 27x27cm^2. The array is independent of energy may utilized in IMRT designs covering small areas, according to the study (Spezi, Angelini, Romani, & Ferri, 2005). Syamkumar et al. demonstrated 2D seven29 is a dependable and exact dosimeter with a valuable quality assurance instrument. The combining of the 2D array and the Octavius phantom is a rapid also dependable approach for checking rotational treatments (Syamkumar, Padmanabhan, Sukumar, & Nagarajan, 2012). To the IMRT patient-specific QA, all plans passed >95 percent gamma with pixels within 4% distance to an agreement of 4 mm (Al-Mohammed & Mahyoub, 2011). The measurements and assessments

allowed for a 2D array for absolute dose quantification in addition can be employed for routine quality assurance controls, such as symmetry, flatness as well as linear accelerator beam penumbra. For using EPID, the average percent of GPs changes by ≤ 05 %, according to the study, this indicate the average percent GP does not appear to be affected by the low-dose threshold irrespective of gamma criterion is employed. Due to the normalizing approach employed in the gamma calculation procedure could be responsible for our findings, Since the maximum value of the dose variation in the low-dose area was relatively higher, the low-dose regions generally passed the gamma analysis. Nelms et al. reported that the global dose difference normalization masks mistakes from lower dose areas and results in gamma analysis insensitivity, particularly to the 3%/3 mm and more approval threshold (Nelms et al., 2013). The low dose is often found in the periphery or penumbra of the target, but, in case low dose is given to a risky organ (OAR), this might lead to harmful effects (Hall & Giaccia, 2006), Nevertheless, low doses can contribute to lung cancer death and heart disease after left side breast cancer radiation treatment (Henson, McGale, Taylor, & Darby, 2013). Song et al. found that there is no crucial effect on patient-specific QA findings on the application of the low-dose threshold to universal standards. The results show that the low dose threshold level must indeed be cautiously set for local normalization since the excluded low dose sites might lead to a fast increase in the average percentage of GP (Song et al., 2015).

We need to compare among three dosimetric in case 3% 3mm because the most common passing criteria which were initially recommended in the work by [low at al] also it was used because TPS algorithms limits at the time when penumbra was a source of uncertainty. Figure 7 shows the comparative average gamma passing rate, by using criterion 3% 3mm fore different dosimetric tools when suppressing the dose threshold below 15%. So, our conclusion implantation of low-dose threshold in global normalization does For the Gafchromic EBT_3 FILM and 2D array ionisation chamber the results of gamma passing increase with increasing low-dose threshold, whilst EPID gamma passing rate results show it has no great influence on the interpretation of patient-specific QA outcomes. Figure 7 shows 3% 3mm of various suppression dose below threshold comparison among three dosimetric tools.

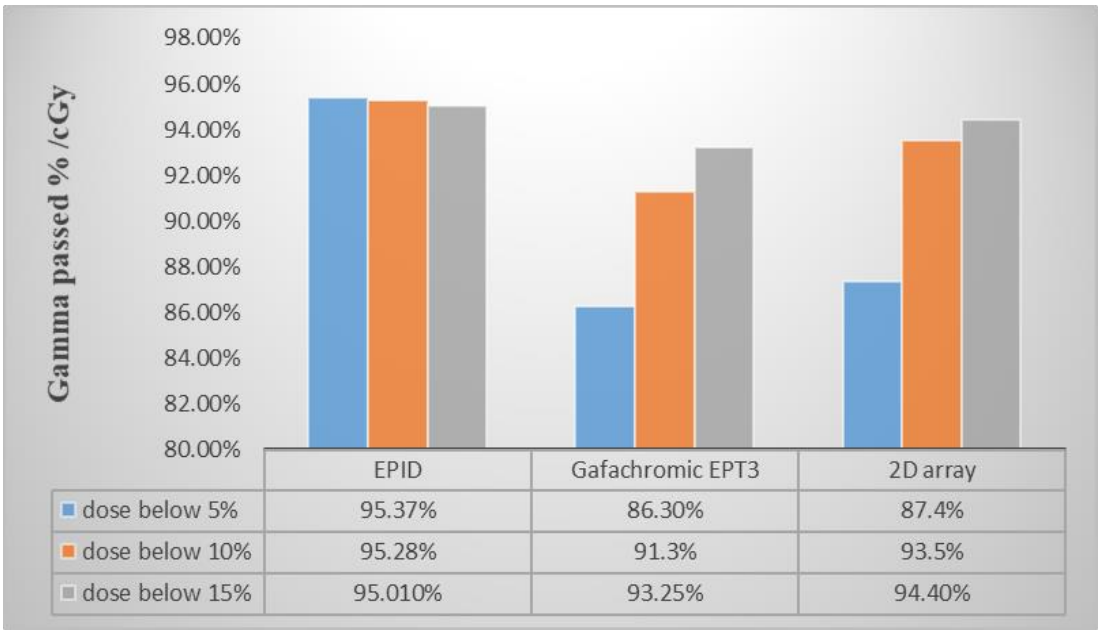

Figure 7. Comparison among three dosimetric tools at 3% 3mm of different suppressing dose below threshold

Conclusion

Radiation therapy treatment planning and delivery will never be perfect, therefore the practical question is "how good is good enough?". In the IMRT method, a successful dose supply is strongly linked to TPS, which must be confirmed by a plan before patient ordination. A thorough understanding the analysis of gamma index along with the equipment and software used is

important. Diverse hardware and software combining show different levels of approval with the expected analysing for the same pass-rate criterion. For a dosimetry audit of the IMRT technique, an EPID detector is superior to conventional methods comparable to Gafchromic EPT3 film and 2D array due to cost, time-consuming, and set up error to get result analysis. For the gamma criterion, 5% DD 5mm DTA for various dosimetric tools produce the best results, as predicted. We studied gamma testing utilizing several low-dose thresholds IMRT patient QA%GP results varied depending on different factors like gamma criteria, dosimeter tools, and suppressing dose below ratio. Every institution should, thus, carefully develop its protocol through establishing the value of gamma index criteria and dosimeter tools for the QA verification routine.

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