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Research Article

Clinical Application of Portal Dosimetry for Pre-treatment Dosimetric Verification Across Various Diagnoses Using Electronic Portal Imaging Integrated with Epibeam

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Abstract

Introduction and Objective: Unlike other LA users, most Elekta users use a 2D Array or other external devices for Patient specific QA purpose. In India, we experimented with a third-party portal dosimetry system called EPI Beam from DosiSoft, France, for PSQA. EPI (Electronic Portal Imaging) Beam Portal Dosimetry is a method used to verify the dose delivery in radiation therapy. It utilizes the Elekta iViewGT EPID to measure the radiation dose distribution delivered to the patient. The acquired portal images are then compared with the predicted dose distribution from the treatment planning system (TPS). The objective of this study is to analyze the gamma pass rate with this technology in various sites and treatment techniques in 100 patients. *Material and methods:* Pre-treatment verification using Portal Dosimetry was performed on 100 patients utilizing an Elekta iViewGT™ EPID and EPI Beam software on an Elekta Harmony Pro linear accelerator having 6 MV, 15 MV, and 6FFF photon energies. Elekta's portal dosimetry system eliminates the need for a separate QA plan or a phantom, as the patient's treatment plan is directly delivered to the Electronic Portal Imaging Device (EPID) panel. The delivered dose is then calculated and compared to the planned dose, ensuring accurate dose delivery and proper linear accelerator functioning before the patient's first treatment fraction. *Results:* In all plans that were done by Volumetric Modulated Arc Therapy (VMAT) for various diagnoses were analyzed and the average gamma pass rate for Head and Neck, Thoracic, Pelvis, Breast, are 99.34%, 98.97%, 98.78% and 99.35% respectively. *Conclusions:* The gamma evaluation indicates a good correlation between predicted and acquired EPID image doses. The EPID-based pre-treatment verification using EPI Beam from DosiSoft is a time-saving and comfortable tool for performing pre-treatment verification. This method enhances the precision and safety of cancer treatments.

Keywords

EPID, Portal Dosimetry, Epibeam, Elekta Medical Systems, Radiation Oncology, Patient Specific Quality Assurances, Pre-Treatment Verification

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1. Introduction

Radiotherapy is one of the modalities to treat more than 50% of cancers, along with surgery and chemotherapy. In Radiation Oncology high end treatments like intensity-modulated radiation therapy (IMRT), volumetric modulated arc therapy (VMAT), stereotactic body radiation therapy (SBRT), and stereotactic radiosurgery (SRS) are stereotactic radiotherapy are used to maximize the benefits by saving the normal structures and by giving high doses to the targets. [1-6].

Patient-specific pre-treatment quality assurance (PSQA) for volumetric-modulated arc therapy (VMAT) is strongly recommended for all patients to identify any potential errors in the treatment planning process and in machine deliverability [7, 8].

Varian Portal Dosimetry (Varian Medical System, Palo Alto, CA) is efficient in implementing portal dosimetry for IMRT and VMAT PSQA due to its incorporation of an Eclipse treatment planning system and amorphous silicon (aSi) EPID. Furthermore, there have been recent advances in Varian Portal Dosimetry, including optimization of the dosimetric response of the aSi imager with incorporation of 2D profile and back scatter corrections [9, 10].

But Elekta harmony pro linear accelerator don't have this inbuilt facility where almost every one use Two-dimensional array detectors to perform per-treatment verification [11-13]. Various tools are used for patient-specific QA to verify the treatment planning. The disadvantage of 2D array is it requires more QA time for phantom setup and its poor spatial resolution [14, 15]. Due to this we chose the third-party Portal dosimetry system, EPI Beam from DosiSoft, France, for PSQA to install in our Elekta Harmony Pro linear accelerator. Several authors presented their results using the EPI beam and compared them with the 2D array to evaluate its effectiveness. [16].

With electronic portal imaging device (EPID) patient setup could be more accurate [17, 18]. Using the EPID digital portal images that were captured were analysed before or during treatment for best patient setup. Another advantage of this tool is the portal dosimetry [19, 20].

In this study, we evaluated the performance of EPID and its dosimetric characteristics on newly installed EPI Beam, EPID on Elekta harmony pro linear accelerator and analyzed the gamma pass rate, which provides comprehensive information on dose differences and distance-to-agreement, across various sites using VMAT techniques in our first 100 patients.

2. Materials and Methods

2.1. Commissioning of Portal Dosimetry

PSQA with VMAT Technology was performed using the amorphous silicon (a-Si) flat panel imager (iViewGT, Elekta, Stockholm, Sweden) attached to the Elekta InfinityHD linear accelerator (Elekta, Stockholm, Sweden). It has a resolution of 1024 × 1024 pixels and a detection area of 41 × 41 cm^2 at a fixed source-to-detector distance (SDD) of 160 cm. The EPID image acquired at SDD 160 cm is automatically converted to SDD 100 cm.

Third Party EPID-based Patient-specific QA software, EPIbeam 1.0.6.31 (DosiSoft, Cachan, France) is used in our Elekta Harmony Pro Linear accelerator as a Portal dosimetry software. Treatment plan images from Monano (V 6.1.2.0) treatment planning system (TPS) from Elekta compared with EPID images from EPIbeam. Portal dosimetry software EPIbeam (version 1.0.6.25) is commissioned based on the vendor recommended procedures. The following tests are performed. Template plans for Monaco TPS users are available to perform tests.

Dark Field and Flood Field: Dark Field and Flood Field were performed to correct the electronic noise and pixel sensitivity equalization respectively.

Dose Calibration: The calibration factor was calculated through the relationship between the iso-center pixel value of EPID and the absorbed dose value calculated using Monaco TPS from Elekta.

Ghosting: After the Dose calibration factor measurement, we corrected the ghost effect. The delay time before acquiring the next image was set differently according to MU. We set the delay time to 15 s (less than 100 MU), 120 s (100 MU), and 180 s (more than 100 MU) as suggested by the vendor.

Gantry sag effect: To achieve accurate characterization of the mechanical sag of the EPID during gantry rotation eight portal images are acquired along the gantry circular trajectory. Portal images at gantry angles 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315° are acquired.

Tongue and Groove: Chair Field and Stair Field Tests from vendor given pretreatment beam data templates were used for analysis.

Portal dose Image Prediction modeling: TPS data (DICOM RT Plan and RT Doses) and EPID images for a set of various field sizes are measured to establish the dose prediction model. Acquired the EPID image for several field sizes (2 ×2, 3 ×3, 6 ×6, 10 ×10, 15 ×15, 20 ×20, and 24 ×24 cm^2).

2.2. EPID Validation Tests

Pre-Treatment beam data templates (Figure 1) from vendors are used to perform Chevron Field Tests, E Field Test and Triangular Field Tests to verify the prediction and conversion models. For gamma analysis, 3% Dose and 3mm distance-to-agreement (DTA) were chosen and the acceptance criterion was gamma agreement index (GAI) > 95%.

2.3. Patient Specific QA

One hundred (100) VMAT cases of various Diagnosis were studied in this Research. All patients Patient specific QA results, Gamma analysis between TPS and measured were analyzed via EPIbeam portal dosimetry were shown in Table 1. We have applied gamma analysis criteria of 3 mm/3% for all the sites with the acceptance criterion of Gamma Index > 95%. All the sites were treated with 6X and with VMAT delivery technique with Two Full ARCS.

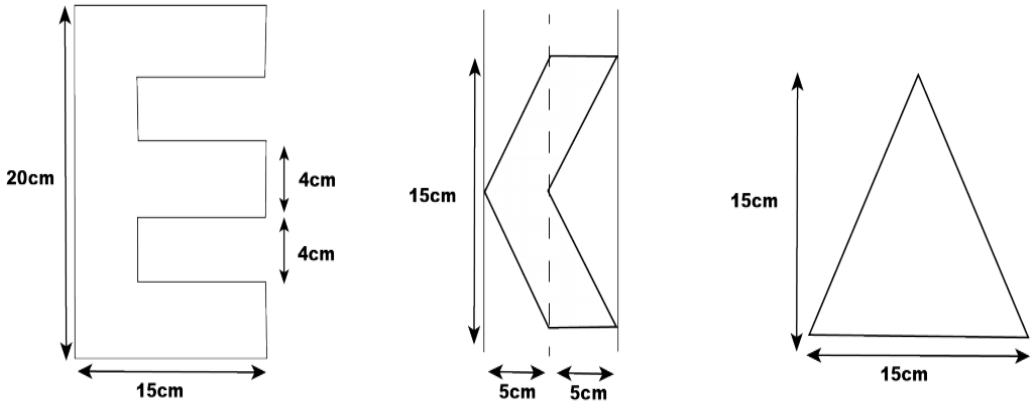

Figure 1. *Pre-Treatment beam data templates.*

3. Results

3.1. Portal Dosimetry Commissioning results

All the images of Dark field, flood field, Dose calibration, Ghosting, gantry sag effect, Tongue and Groove, portal dose images that were acquired in the main iViewGT are saved to the sub-folder of EPIbeam Pre-Treatment commissioning data as specifed by the vendor. All the images that acquired were satisfactory and are within the manufacturer specifications.

3.2. EPID Validation Test Results

Gamma analysis for three verification fields (E field, triangle field, and chevron field) were within 3% of dose and 3mm of DTA (Figure 2 to Figure 4).

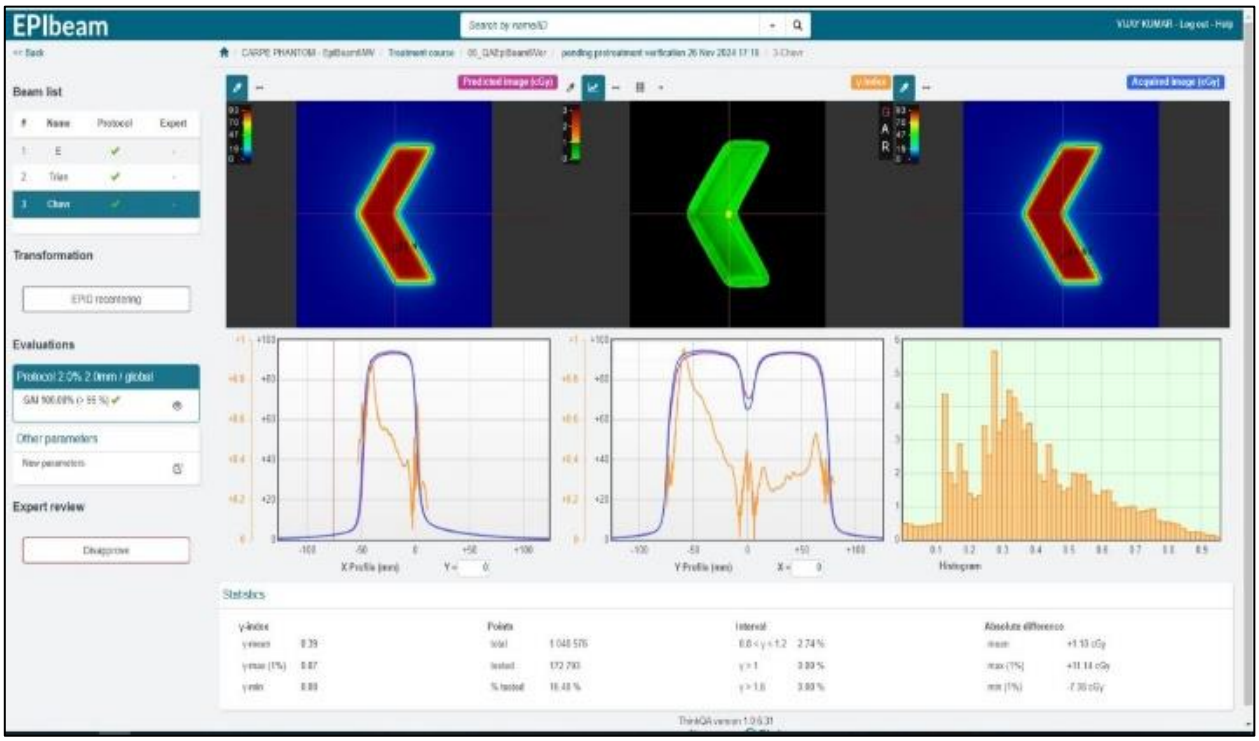

Figure 2. *Gamma Analysis of Chevron Field in Epibeam.*

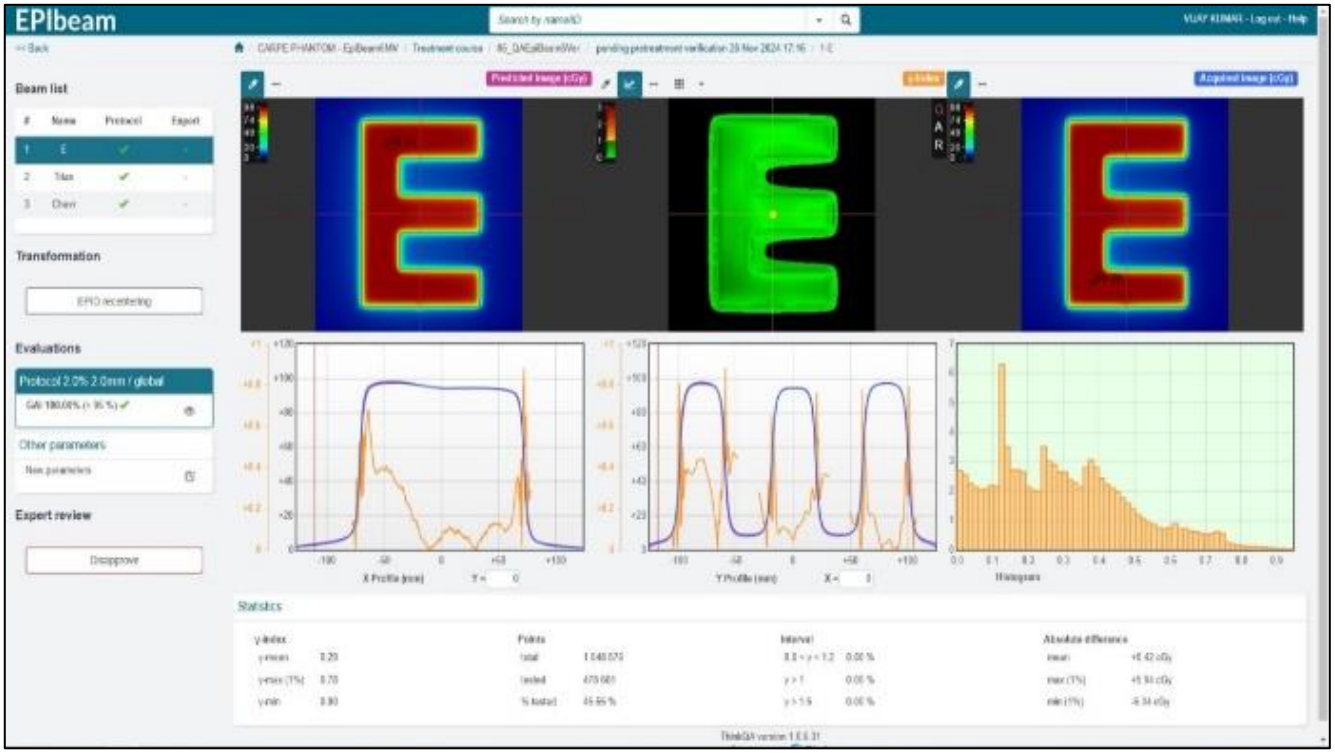

Figure 3. *Gamma Analysis of E Field in Epibeam.*

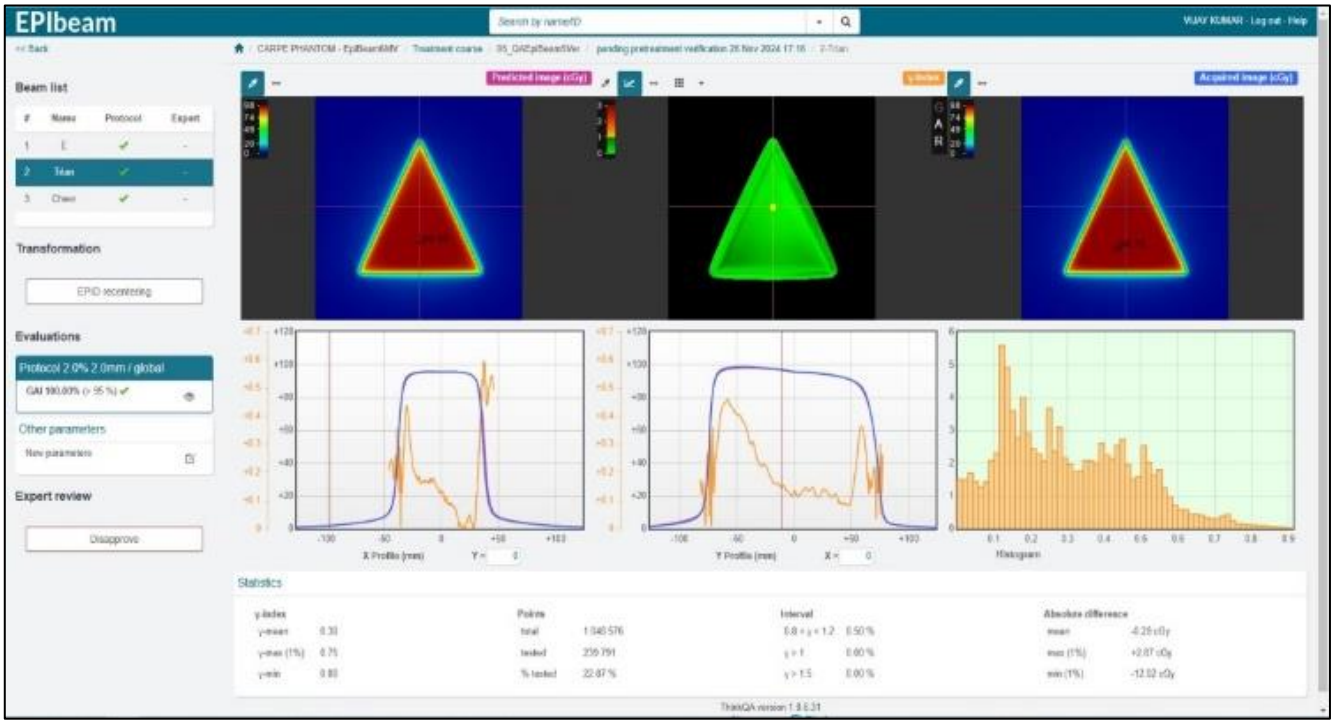

Figure 4. *Gamma Analysis of Triangle Field in Epibeam.*

All fields passed based on 3 mm/3% (local), GAI > 95% (Table 1). This proved that EPID Validation tests are pass and it is a successful commissioning of EPIbeam. The gamma passing rates are shown below.

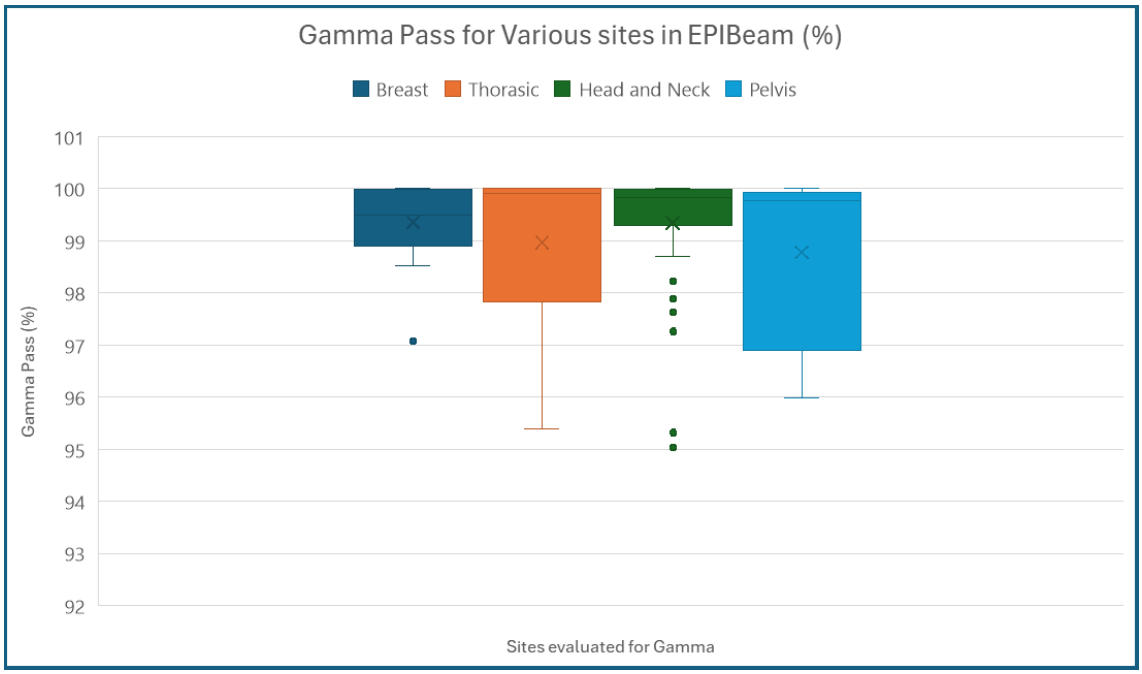

Figure 5. *Gamma Pass Index for Breast, Thorax, Head and Neck and Pelvis Cases.*

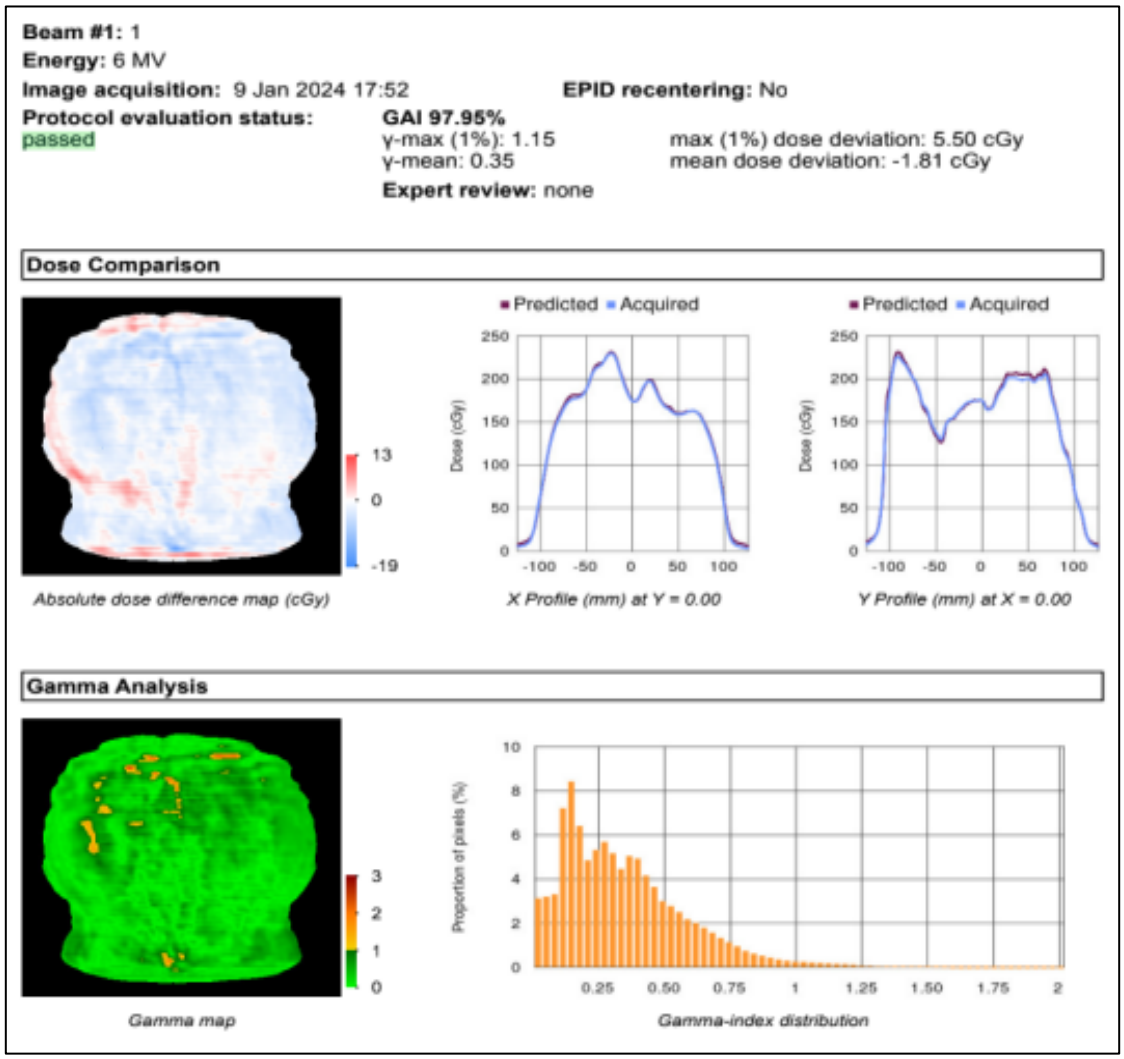

Figure 6. *PSQA in EPIbeam in Elekta Harmony Pro Linear accelerator.*

Table 1. Gamma analysis results of commissioning verification of three QA plans for 6 MV.

Gamma analysis results of commissioning verification of three QA plans for 6 MV					
	Field	**DTA (mm)**	**DD (%)**	**GAI (%)**	**Energy**
1	E field,	2	2	100	6MV
2	Triangle field	2	2	100	6MV
3	chevron field	2	2	100	6MV
1	E field,	2	2	98.95	6MV FFF
2	Triangle field	2	2	100	6MV FFF
3	chevron field	2	2	100	6MV FFF
1	E field,	2	2	100	15MV
2	Triangle field	2	2	100	15MV
3	chevron field	2	2	100	15MV

3.3. Patient Specific QA-Gamma Analysis

Gamma analysis was performed by applying the 3 mm/3% criteria for all the 100 VMAT cases for various sites; The Gamma pass rates for Breast, Thorax, Head and Neck, and Pelvis cases are presented in Figure 5, while the PSQA results using EPIbeam on the Elekta Harmony Pro Linear Accelerator are illustrated for a single case in Figure 6. The average gamma pass rate for Head and Neck, Thoracic, Pelvis, Breast, are 99.34%, 98.97%, 98.78% and 99.35% respectively.

4. Discussion

The paper addresses solutions for pre-treatment, patient-specific quality assurance (PSQA) for linear accelerators that lack vendor-provided portal dosimetry software. Varian Portal Dosimetry (Varian Medical System, Palo Alto, CA) is available in all Varian linear accelerators, and it is efficient in implementing portal dosimetry for IMRT and VMAT PSQA due to its incorporation of an Eclipse treatment planning system and amorphous silicon (aSi) EPID. Whereas Elekta and few other Linear accelerators don't have this facility. By utilizing an existing electronic portal imaging device (EPID) in combination with third-party portal dosimetry software, it demonstrates that high-quality PSQA can be achieved in any Linear accelerators without inbuilt portal dosimetry facility for any treatment site.

The linear accelerator employed in this study is the Elekta Harmony Pro, and the software used is EPIbeam version 1.0.6.31, developed by DosiSoft, Cachan, France. Initial quality assurance tests were conducted on the EPID to assess its stability, accuracy, and suitability using three gamma tests (E-field, triangle field, and chevron field), all of which achieved a Gamma Index of over 98%. Subsequently, EPID measurements were performed on 100 cases across various diagnoses, involving a total of 100 patients. The results showed agreement levels exceeding 96%, enabling the safe implementation of treatment plans on the accelerator.

5. Conclusions

The gamma evaluation indicates a good correlation between predicted and acquired EPID image doses. The EPID-based pre-treatment verification using EPI Beam from DosiSoft is a time-saving and comfortable tool for performing pre-treatment verification in Elekta Linear Accelerators for various treatment sites. This method enhances the precision and safety of cancer treatments. This technology offers a viable solution for any linear accelerator without built-in portal dosimetry capabilities. Furthermore, it can be integrated into existing linear accelerators to enhance the quality of patient treatments.

Abbreviations

EPID	Electronic Portal Imaging Device
PSQA	Patient Specific Quality Assurance
Epibeam	Electronic Portal Imaging Beam
VMAT	Volumetric Modulated Arc Therapy
SBRT	Steriotactic Body Radiotherapy

Conflicts of Interest

The authors declare no conflicts of interest.

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