RESEARCH ARTICLE

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Feasibility Study of Using Kv-Cone Beam CT Images as Patient Specific Quality Assurance Tool

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Abstract

Purpose: Patient-specific quality assurance (PSQA) typically involves the comparison between the planned fluence and the delivered fluence of a routine CT (Computed Tomography)-based radiotherapy plan. In contrast the study focuses on evaluating the kV-CBCT (Kilovoltage Cone beam Computed Tomography) image set as a potential tool for assessing the delivered dose for images of same cervical cancer patient, enabling the daily assessment and verification of planned dose distributions. **Methods:** This research comprised 13 cervical cancer patients who received treatment at the Department of Radiation therapy and Oncology, Kasturba Hospital, Manipal, between 2023 and 2024. Monaco software-5.11.03 was used for image registration, segmentation and treatment planning. Planned fluence verification was analysed using the PTW MEPHYSTO software, a fluence comparison tool. **Results:** Minor, statistically insignificant differences were observed in dose distribution between kVCBCT and routine CT image-based plans. The planned fluence on kVCBCT images met gamma criteria for most cases, with occasional deviations in specific anatomical planes. **Conclusion:** This study sums up that the dose distribution and planned fluence on kVCBCT images effectively correlated with planning CT images, thereby supporting the daily verification and assessment of planned dose distributions using kVCBCT images for cervical cancer cases.

Keywords: kV CBCT- HU- Electron density- PSQA- Dose calculation

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Introduction

Radiation therapy currently employs conformal techniques, such as three-dimensional conformal radiation and intensity-modulated radiation, to deliver high doses to the tumour while minimizing exposure to surrounding healthy tissues. These methods create a sharp dose gradient, but the steep decline at target-volume edges mean that even minor misalignments can lead to a geographic miss [1-4].

As a result, conformal treatment setups now require three-dimensional verification. In-room imaging techniques like megavoltage cone-beam CT (MVCBCT) and kVCBCT facilitate accurate patient positioning and target localization. [5-7]. kVCBCT images provide a three-dimensional perspective of the patient during pre-treatment verification, making it possible to reconstruct the treatment plan's delivered dose in 3D which provides the ability to perform dose distribution calculations, which allows for the daily assessment and verification of planned dose distributions of routine CT image-based plans with kVCBCT images of the same patient. The accuracy of dose calculations using kVCBCT images depends largely on the precise correlation between Hounsfield Unit (HU) values and relative electron densities (RED) [8-12]. The comparison of dose distribution between Volumetric Modulated Arc Therapy (VMAT) plans of CT and kVCBCT images is evaluated in terms of planned fluence, with the evaluation conducted using 3D gamma analysis [13-23]. Various studies have explored approaches to ensure clinically acceptable accuracy in dose calculations for treatment planning and 3D dose reconstruction with CBCT images of several sites such as lung tumours, head and neck, palliative cases [24-28]. Its use in cervix cancer cases is still limited.

Further, PSQA typically involves comparing the planned fluence with the delivered fluence in a routine CT-based radiotherapy plan.The absence of exit dose analysis in this study limits the ability to provide actual delivered dose measurements. However, in this study effort is made to understand pretreatment DVH (Dose-Volume Histogram) or to be delivered DVH during treatment position verificaiton using kV-CBCT.. In conclusion, the features and capabilities of kV-CBCT images highlighted

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in this study prompted an investigation into their feasibility as a PSQA tool for verifying the planned fluence in cervix cancer cases, which could enable daily evaluation and confirmation of the planned dose distributions.

Materials and Methods

Patient selection

The research comprised 13 cervical cancer patients who received treatment at the Department of Radiotherapy and Oncology, Kasturba Hospital, Manipal, between 2023 and 2024. All patients underwent VMAT with a prescribed dose of 45Gy in 25 fractions. Following this, kVCBCT images for these patients were obtained within one day of their CT scan acquisition.

Equipment

Patients were immobilized using a thermoplastic pelvic mold. The routine planning CT scans were acquired using a Philips Big bore 16-slice CT scanner. kVCBCT images were acquired from an X-ray volume imaging system (XVI) in Elekta versa HD linear accelerator which comprises two robotic arms mounted on the gantry, oriented perpendicular to the radiation beam. It employs an a-Si flat panel detector with a 42.5 × 42.5 cm active imaging area, allowing for flexibility in choosing the field of view (FOV) for different anatomical regions. A medium FOV (Half fan CBCT) is standard for larger areas (pelvic region). The XVI is equipped with preset parameters designed for specific anatomical sites, including imaging geometry, beam characteristics, and reconstruction methods. Moreover, it permits customization of tube potential, frame count, mAs and kVp per frame, start and stop gantry angles, and reconstruction resolution [20]. The resulting CT and kVCBCT images were then transferred to the Monaco Treatment Planning System (TPS) [29]. In this study, the CATPHAN503 (CTP503) phantom was used for HU and E.D calibration between CT and kVCBCT images.

CTP503 for calibration of HU/E.D for kVCBCT and CT imaging modalities

The CTP503 phantom serves as a tesing tool specifically designed to measure image quality metrics on both CT scanners and kVCBCT scanners [10]. The assessment of kVCBCT volume image quality includes the correlation between HU and electron density. Variations in tissue composition can affect the distribution of radiation dose, especially with the increasing use of conformal external beam radiotherapy (EBRT), which heightens the risk of inadequate dose coverage around the target area [30]. Therefore, it's crucial to understand uncertainties before incorporating kVCBCT and CT images into treatment planning [30].

Treatment Planning Process

Image Registration

Prior to commencing treatment planning, the CT and kVCBCT images of cervical cancer patients acquired from the CT scanner and the XVI guidance system respectively in the LINAC were fused or overlaid. Visual verification that corresponding anatomical features on the two scans matched was done to assess the level of agreement of registration between the two images. The clearly visible bony landmarks on both CT and kVCBCT images were taken as the object pairs to be matched. This was facilitated by point-to-point image fusion tools in the MONACO TPS, which included vertical strips, horizontal strips, checkboard method, and fused image between CT and kVCBCT images as shown in Figure 1.

Image segmentation

Targets including Gross Tumor Volume (GTV), Clinical Target Volume (CTV), Planning Target Volume

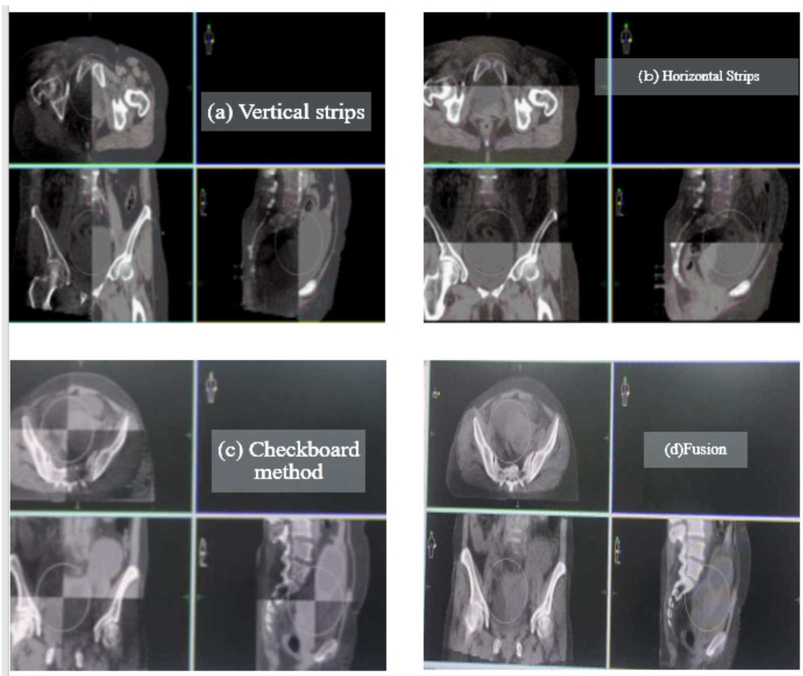


Figure 1. Routine CT and kVCBCT Images were Anatomically Fused

(PTV) and organs at risk (OARs) such as the bladder, rectum, bowel bag, right and left femur were delineated in both planning CT and kVCBCT images, as shown in Figure 2.

Treatment Planning with VMAT

Treatment planning using VMAT technique was performed on Monaco TPS (5.11.03) on routine CT and kVCBCT images. Clinically approved plans of CT images were overlapped on the kV-CBCT image dataset without changing any planning parameters. A prescribed dose of 45Gy in 25 fractions, consistent with the existing routine CT image-based plan, was used. The beam arc directions, beam energy (6MV), and IMRT constraint parameters for PTV as well as OARs from the existing CT image-based plan, were replicated on the corresponding kVCBCT images for the same patients as shown in Figure 3. The best final kVCBCT-image based VMAT plan was considered for comparison purposes with CT image plans.

Plan Evaluation

HI and CI Parameters were assessed to compare the dose distribution in PTV between routine CT image and kVCBCT-image based plans.

Conformity index (CI) = VRI/ TV.

Where VRI is Volume reference isodose volume and TV is target volume. Here we took the reference isodose volume as the 100% isodose. The CI value ranges between 0 and 1, with an optimal value of 1, indicating a high level of conformity where the entire prescribed dose is concentrated within the PTV.

Homogeneity Index (HI) = Imax / RI.

Where Imax is maximum isodose and RI is reference isodose. The homogeneity of the dose distribution is considered optimal when the HI value approaches 1, indicating uniformity.

Planned fluence verification

For dose distribution verification, TPS fluence was created for both CT and kVCBCT image-based plans. The gamma passing rates were compared between the CT plans and kVCBCT image-based plans for 13 cervix cancer cases at the criteria of applying a dose-difference (DD) criterion of 3% and 3mm distance-to-agreement (DTA) criterion. Also, we evaluated the results using the stricter 3% DD / 2 mm criteria recommended by the AAPM TG218 protocol for comparison. As shown in Figure 4, fluence maps were used to analyse the fluence in the coronal, sagittal, and transverse planes. Additionally, a volume analysis was done. The gamma index was calculated using the PTW MEPHYSTO software, a fluence comparison tool.

Results

HU and E.D Assessment

Table 1 presents the HU range and relative electron density (RED) values for various inserts material when scanned using CATPHAN503 for CT and kVCBCT imaging systems. For air, the HU values are consistent between CT (-967) and kVCBCT (-968), with similar RED values of 0.034 and 0.033, respectively, indicating minimal variation. However, differences between the two

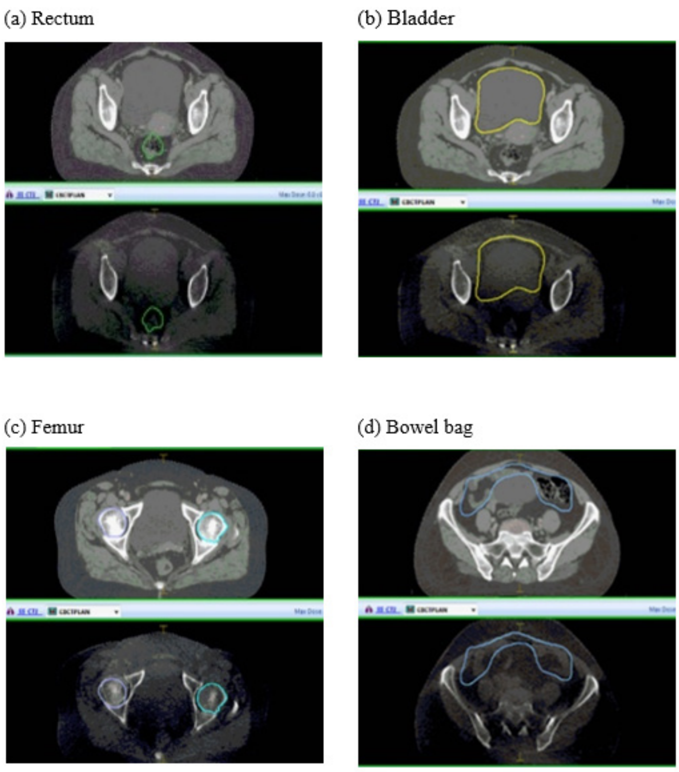


Figure 2. Rectum, Bladder, Femur and Bowel Bag Contoured on Routine CT and kVCBCT Images

Table 1. Calibration of HU and ED of CT and kVCBCT

Material	HU range		Relative Electron density	
	CT	kVCBCT	CT	kVCBCT
Air	-967	-968	0.034	0.033
PMP	-165	-391	0.893	0.6377
LDPE	-82	-329	0.976	0.767
Polystyrene	-27	-291	1.02	0.75
Delrin	346	-15	1.205	1.029
Teflon	921	410	1.556	1.244

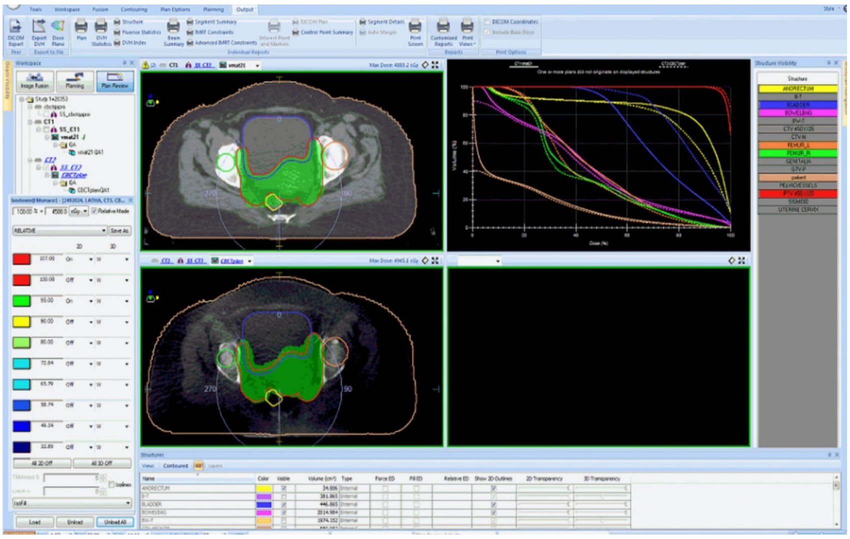
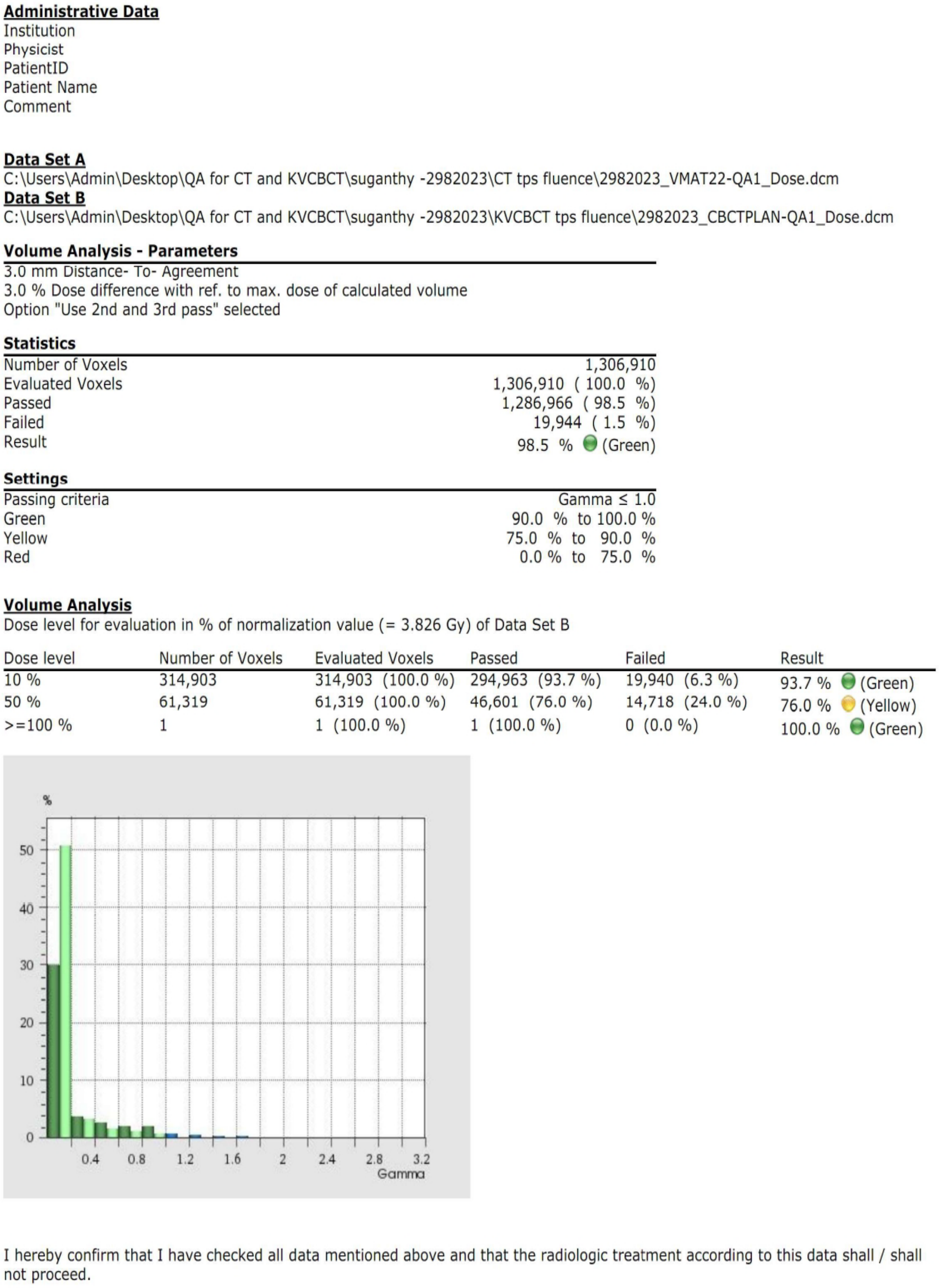


Figure 3. 95% Dose Distribution of VMAT Plan in PTV Contour of Both Routine CT and kVCBCT Transverse Images of Cervix Cancer

imaging modalities become more pronounced for other materials. Polymethylpentene shows a significant drop in HU from -165 (CT) to -391 (kVCBCT), with its RED decreasing from 0.893 to 0.6377, suggesting KVCBCT may underestimate density for low-density polymers. A similar trend is observed with Low-Density Polyethylene (HU: -82 vs. -329), where the RED value decreases from 0.976 to 0.767. Polystyrene follows the same pattern, with HU values shifting from -27 (CT) to -291 (kVCBCT), and RED decreasing from 1.02 to 0.75. Interestingly, Delrin

Table 2. Comparison of CT Image VMAT Plan and kVCBCT Image VMAT Plan p-value of Dosimetric Parameters for Target and OARs

VMAT	Parameters	CT Image Plan Mean±Sd	kVCBCT Image Plan Mean±Sd	CT Image Plan VS kVCBT Image Plan (p value)
Bladder	V95%(%)	97.511±1.55	91.490±11.56	0.105
	V100%(%)	59.990±11.53	53.850±29.15	0.348
	D95%(Gy)	4341.712±41.82	4012.050±10.82	0.193
	D100%(Gy)	5679.600±84.09	4995.188±97.30	0.433
	CI	0.624±0.16	0.538±0.29	0.205
	HI	1.094±0.02	1.064±0.09	0.093
	Mean Dose	3750.887±392.04	3781.725±369.02	0.555
Rectum	D2CC	4676.669±73.13	4658.012±76.03	0.199
	Mean Dose	4058.763±374.12	4030.588±415.13	0.481
Bowel Bag	D2CC	4615.797±57.36	4611.656±81.97	0.802
	Mean Dose	1826.706±648.54	1756.956±734.73	0.298
Right Femur	D2CC	4298.019±10.48	4663.325±62.00	0.375
	MaxDose	4285.49±282.04	4274.369±311.00	0.211
Left Femur	Max Dose	4338.000±302.86	4268.325±278.44	0.495



Administrative Data
Institution
Physicist
PatientID
Patient Name
Comment

Data Set A
C:\Users\Admin\Desktop\QA for CT and KVCBCT\suganthy -2982023\CT tps fluence\2982023_VMAT22-QA1_Dose.dcm
Data Set B
C:\Users\Admin\Desktop\QA for CT and KVCBCT\suganthy -2982023\KVCBCT tps fluence\2982023_CBCTPLAN-QA1_Dose.dcm

Volume Analysis - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose difference with ref. to max. dose of calculated volume
Option "Use 2nd and 3rd pass" selected

Statistics

Number of Voxels	1,306,910
Evaluated Voxels	1,306,910 (100.0 %)
Passed	1,286,966 (98.5 %)
Failed	19,944 (1.5 %)
Result	98.5 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Volume Analysis
Dose level for evaluation in % of normalization value (= 3.826 Gy) of Data Set B

Dose level	Number of Voxels	Evaluated Voxels	Passed	Failed	Result
10 %	314,903	314,903 (100.0 %)	294,963 (93.7 %)	19,940 (6.3 %)	93.7 % (Green)
50 %	61,319	61,319 (100.0 %)	46,601 (76.0 %)	14,718 (24.0 %)	76.0 % (Yellow)
>=100 %	1	1 (100.0 %)	1 (100.0 %)	0 (0.0 %)	100.0 % (Green)

I hereby confirm that I have checked all data mentioned above and that the radiologic treatment according to this data shall / shall not proceed.

Figure 4 (a). Tumor Volume Analysis Using Gamma Index Analysis Using 3%/3mm Criteria between kVCBCT and Routine CT Image based VMAT Plan Passing with a Result of 98.5%.

shows a minimal change in RED (1.205 for CT and 1.029 for kVCBCT) despite its HU changing from 346 to -15. Lastly, Teflon demonstrates a significant drop in RED from 1.556 (CT) to 1.244 (kVCBCT), with HU values shifting from 921 (CT) to 410 (kVCBCT). These discrepancies highlight the differences in material characterization between CT and kVCBCT, especially for denser or low-attenuation materials, which can impact accuracy in dose calculations and treatment planning.

Dosimetric Assessment

In Figure 3 the comparison of plans between CT and kVCBCT images was made using Dose Volume Histogram (DVH) as one of the parameters for Dosimetric evaluation. In Table 2 the CT planned method shows a higher V95% value (97.511%±1.55) compared to kVCBCT planned (91.490±11.5644), indicating better coverage of at least 95% of the prescribed dose to the target volume. Similarly, CT planned has a higher V100% value (59.990%±11.538) compared to kVCBCT planned (53.850%±29.152), indicating better coverage of the entire prescribed dose to the target volume. The dose received by 95% of the target volume is higher with CT planned (4341.712 Gy±41.820) compared to kVCBCT planned (4012.050 Gy±10.82). CT planned also shows a higher D100% value (5679.600 Gy±84.09) compared to kVCBCT planned (4995.188

Administrative Data
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Data Set A
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Slice: 0.00 mm
Data Set B
C:\Users\Admin\Desktop\QA for CT and KVCBCT\suganthy -2982023\KVCBCT tps fluence\2982023_CBCTPLAN-QA1_Dose.dcm

Gamma 3D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose difference with ref. to max. dose of calculated volume
Option "Use 2nd and 3rd pass" selected

Statistics

Number of Dose Points	11,881
Evaluated Dose Points	11,881 (100.0 %)
Passed	11,715 (98.6 %)
Failed	166 (1.4 %)
Result	98.6 % (Green)

Gamma 3D

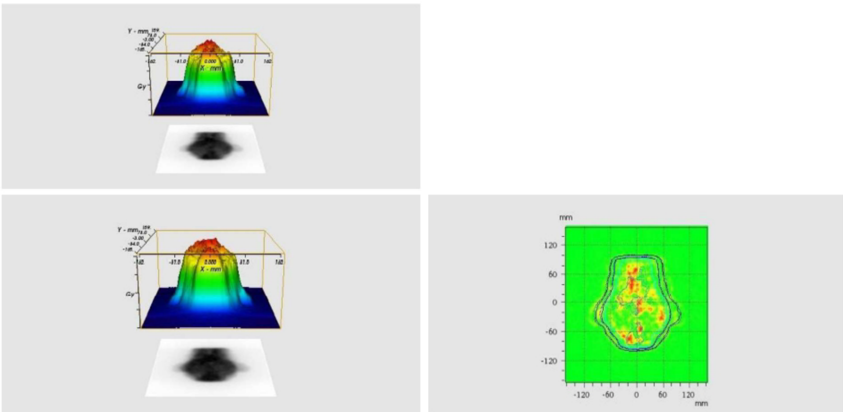
Arithmetic Mean	0.133
Min (LR = -162.0 mm; TG = 159.0 mm)	0.000
Max (LR = -9.0 mm; TG = 48.0 mm)	1.602
Median	0.034

Absolute Difference

Arithmetic Mean	0.018 Gy
Min (LR = -162.0 mm; TG = 159.0 mm)	0.000 Gy
Max (LR = -9.0 mm; TG = 48.0 mm)	0.236 Gy
Median	0.004 Gy

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %



I hereby confirm that I have checked all data mentioned above and that the radiologic treatment according to this data shall / shall not proceed.

Figure 4 (b). Report of Coronal Plane Passing Gamma3D Analysis with 98.6%.

Gy±97.30), indicating better overall dose delivery to the target volume. The mean dose and D2CC for organs at risk (bladder, rectum, bowel bag, femurs) did not show significant differences between CT planned and kVCBCT planned. The conformity index and homogeneity index of VMAT plans in Table show slightly better values for CT planned (CI: 0.624±0.163, HI: 1.094±0.0221) compared to kVCBCT planned (CI: 0.538±0.291), (HI: 1.064±0.094).

Planned Fluence assessment

In Table 3 and Figure 4(a,b,c,d), the values in percentage among all anatomical planes and volumes are compared between routine CT and kVCBCT image-based plans. The data compares gamma passing rates (%) between CT and kVCBCT images across three planes at isocentre: coronal, sagittal, transverse, and volume analysis, using 3%/3mm and 3%/2mm tolerances. The mean gamma passing rate is highest in the volume analysis (91.4% for 3%/3mm, 89.4% for 3%/2mm), indicating superior alignment and dose consistency in 3D assessments. In contrast, the sagittal plane shows the lowest performance, with means of 79.4% (3%/3mm) and 76.8% (3%/2mm), and a minimum value of 55.9%, suggesting possible challenges in anatomical alignment or motion management in this plane. The coronal plane exhibits relatively stable results, with a mean of 88.2% and minimal variability (STD: 8.47). The transverse plane shows moderate performance (mean: 83.6%).

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Data Set A
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Slice: 0.00 mm
Data Set B
C:\Users\Admin\Desktop\QA for CT and KVCBCT\suganthy -2982023\KVCBCT tps fluence\2982023_CBCTPLAN-QA1_Dose.dcm

Gamma 3D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose difference with ref. to max. dose of calculated volume
Option "Use 2nd and 3rd pass" selected

Statistics

Number of Dose Points	11,990
Evaluated Dose Points	11,990 (100.0 %)
Passed	10,617 (88.5 %)
Failed	1,373 (11.5 %)
Result	88.5 % (Yellow)

Gamma 3D

Arithmetic Mean	0.401
Min (LR = -162.0 mm; TG = 159.0 mm)	0.000
Max (LR = -144.0 mm; TG = 60.0 mm)	3.015
Median	0.229

Absolute Difference

Arithmetic Mean	0.058 Gy
Min (LR = -162.0 mm; TG = 159.0 mm)	0.000 Gy
Max (LR = -153.0 mm; TG = -15.0 mm)	0.444 Gy
Median	0.032 Gy

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

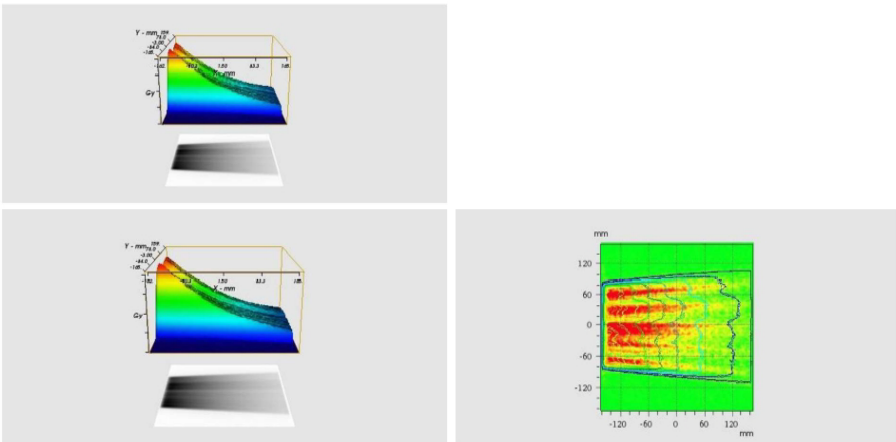

Figure 4 (c). Report of Sagittal Plane Passing Gamma3D Analysis with 88.5%

Maximum values across all planes indicate that optimal performance can reach over 95% passing rates, especially for volume analysis, while the lower minimums highlight inconsistencies in some cases.

Discussion

This study investigated the feasibility of reproducing the treatment plan on kVCBCT images by replicating the treatment plan of routine CT images of same cervix cancer patients. Once the plan was performed on kVCBCT images, the dose distribution and planned fluence of kVCBCT image-based plans were evaluated to provide a result whether the dose distribution and planned fluence were twining with routine CT image-based plans.

Therefore, in our study the initial step was image acquisition, with a similar number of slices in both sets of images. The visual inspection compares the registration only in some image regions and is not a global verification, it is necessary to delineate the target volume and OARs in routine CT planning images and kVCBCT images. It is feasible to administer a maximum dose from prescribed dose to the entire PTV contour using VMAT planning on CT and kVCBCT images. For target coverage, VMAT demonstrated slightly higher V95% and V100% values in CT image plans compared to KVCBCT, albeit with p-values of 0.105 and 0.348 respectively, indicating insignificant differences. However, dose parameters for the target showed no statistically significant distinctions between the two imaging modalities. Regarding organ

Administrative Data
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Data Set A
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Slice: 0.00 mm
Data Set B
C:\Users\Admin\Desktop\QA for CT and KVCBCT\suganthy -2982023\KVCBCT tps fluence\2982023_CBCTPLAN-QA1_Dose.dcm

Gamma 3D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose difference with ref. to max. dose of calculated volume
Option "Use 2nd and 3rd pass" selected

Statistics

Number of Dose Points	11,990
Evaluated Dose Points	11,990 (100.0 %)
Passed	11,508 (96.0 %)
Failed	482 (4.0 %)
Result	96.0 % (Green)

Gamma 3D

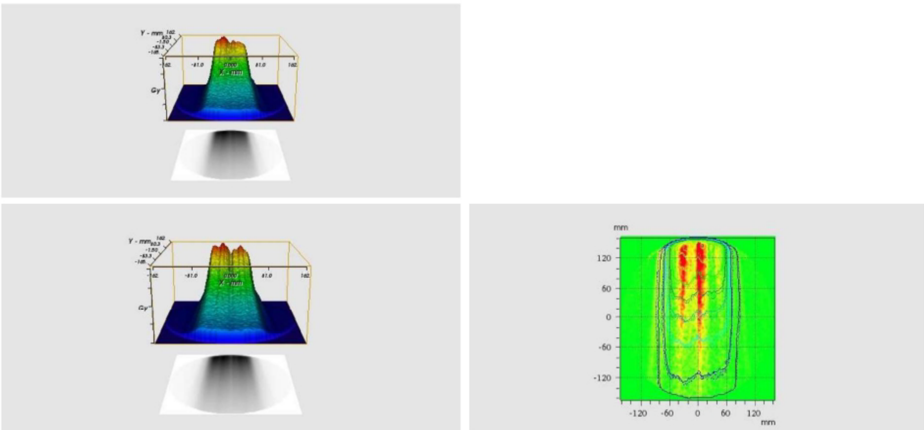
Arithmetic Mean	0.236
Min (LR = -162.0 mm; TG = 162.0 mm)	0.000
Max (LR = 3.0 mm; TG = 141.0 mm)	2.853
Median	0.095

Absolute Difference

Arithmetic Mean	0.034 Gy
Min (LR = -162.0 mm; TG = 162.0 mm)	0.000 Gy
Max (LR = 3.0 mm; TG = 153.0 mm)	0.424 Gy
Median	0.011 Gy

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %



I hereby confirm that I have checked all data mentioned above and that the radiologic treatment according to this data shall / shall not proceed.

Figure 4 (d). Report of Transverse Plane Passing Gamma3D Analysis with 96.0%

at risk sparing, both bladder and rectum exhibited comparable mean doses and D2CC values in CT and kVCBCT image plans, with p-values indicating no significant variation. Notably, the bowel bag showed similar trends in mean dose but a significant difference in D2CC, suggesting potential variation in high-dose regions. Consistent maximum doses were noted for both femurs across imaging modalities, with p-values indicating no significant differences. The C.I and H.I of VMAT plans show slightly better values for CT planned images compared to kVCBCT planned images. Finally, the analysis of dose distribution data between CT-based and kVCBCT-based treatment plans showed only minor differences. This outcome led to the next phase of the research, focusing on investigating the planned fluence variations between CT and kVCBCT images.

The Overall planned fluence of kVCBCT image-based plans demonstrated strong alignment with that of routine CT image-based plans, as assessed based on the gamma criteria (as seen in the volume analysis). In Figure 4(a) Volume analysis provides the highest gamma passing rates, suggesting improved accuracy. There were some inconsistencies in individual anatomical planes, particularly in the sagittal and transverse planes shown in Figure 4 (b,c,d). The variability indicates that factors, such as patient positioning variation with increasing distance

Table 3. This Table Provides a Quantitative Assessment of the Percentage of Pixels Passing the Gamma Criteria 3% / 3Bmm and 3%/2Bmm for the Planned (TPS) Fluence of CT AND KVCBCT image based VMAT plans across three anatomical planes coronal, sagittal, and transverse and volume analysis among 13 patients.

S.no	Planned Fluence (Gamma Passing Rate %) Between CT And kVCBCT Images							
	Coronal		Sagittal		Transverse		Volume Analysis(%)	
	3%/3mm	3%/2mm	3%/3mm	3%/2mm	3%/3mm	3%/2mm	3%/3mm	3%/2mm
1	95.3	94.1	83.8	81.9	91.9	90.4	96.4	95.4
2	97.3	96.7	83.4	81.3	95.9	95	97.4	96.8
3	80	78.5	64.6	61.7	74.1	72.3	84.6	83.2
4	97.1	96.5	92.8	90.1	92.7	91	97.4	96.7
5	80.4	79.4	55.9	54.4	62	60.8	93.3	82.3
6	92.5	90.9	80.5	75.7	93.8	92.4	93.6	92
7	87.9	86	87.9	84.1	84.6	82.1	90.3	88.7
8	79.8	77.4	95.7	94.3	73.1	71.1	85.2	83.61
9	83.7	82.2	74.7	71.4	69.7	67.2	86.8	85.4
10	90.9	89.6	75.9	73.2	83.8	81.4	93.1	92
11	92.2	90.5	90.4	88	97.7	97.1	93.8	92.2
12	98.6	98.1	88.5	86.3	96	95	98.5	98
13	71.5	69.8	58.3	56.5	72.1	70.6	77.2	75.8
MEAN	88.2	86.9	79.4	76.8	83.6	82	91.4	89.4
Std.Dev	8.47	8.82	12.94	12.86	12.09	12.37	6.28	6.85
Max	98.6	98.1	95.7	94.3	97.7	97.1	98.5	98
Min	71.5	69.8	55.9	54.4	62	60.8	77.2	75.8

from the isocenter, organ motion, HU variance between the two scans could also contribute to the observed differences across all dimensions.

In conclusion, kVCBCT images successfully facilitated registration, contouring, treatment planning in cervical cancer patients planned for teletherapy, and enables the dose distribution calculations, facilitating the daily assessment and verification of planned dose distributions of routine CT-based plans.. I hypothesize that kV-CBCT images can be effectively used as a tool for PSQA to evaluate planned fluence. However, we also propose that a comprehensive PSQA procedure should extend beyond planned fluence evaluation to include an assessment of the delivered fluence of treatment plans, which could provide a more accurate verification of treatment to be delivered.

Author Contribution Statement

Bose Nathaniel V, Data collection and Article Drafting. Mr. Srinidhi Gururajarao Chandraguthi, concept and design of the Work, article drafting, and critical revision. Shreekripa rao, critical revision of the article; Rechal Nisha Dsouza, Critical revision of the article.

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Approval

Approved by Institutional Research Committee (IRC) and Institutional Ethics Committee (IEC)

Ethical Declaration

Ethical clearance for this study was obtained from Kasturba Medical College and Kasturba Hospital Institutional Ethics Committee because the CT and KVCBCT images that were used in this study were extracted from the picture archive communication system (PACS) of Kasturba Hospital.

Was the study registered in any registration dataset

No, this study is not registered in any registration dataset.

Conflict of Interest

All authors declare no conflict of interest.

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