International Journal Dental and Medical Sciences Research
Volume 5, Issue 4, July-Aug 2023 pp 578-586 www.ijdmsrjournal.com ISSN: 2582-6018

Patient-Specific Quality Assurance Gamma Analysis for Various Treatment Sites by using Portal Dosimetry

Mallikarjuna Adavala [1], K. Chandrasekhar Reddy [2], Shakambari Sadangi [3]
1 Department of Physics, Rayalaseema University, Kurnool, AP, India & AIG Hospitals, Gachibowli, Hyderabad, India
2 Department of Physics, Govt Degree College, Uravakonda, AP, India
3 Department of Radiation oncology, AIG Hospitals, Gachibowli, Hyderabad, India

Date of Submission: 20-08-2023 Date of Acceptance: 31-08-2023

ABSTRACT: The aim of this study was to perform patient-specific Quality Assurance (PSQA) for VMAT plans using portal dosimetry for patients with various treatment sites. Data analysed at three different criteria. We have selected 15 patients randomly for each treatment site including liver, pancreas, brain, head & neck, oesophagus, stomach, colon, lung, prostate, cervical and breast. For each treatment site, three different gamma criteria were considered: 3%3mm, 3%2mm, and 2%2mm. Measured dose were compared with predicted dose to assess the agreement and quantify any discrepancies.

RESULTS: The average agreement between the measured and calculated dose distributions was computed for each treatment site and criterion. The liver and pancreas showed relatively good agreement, with average deviations of 0.39 and 0.44, respectively, for the 2%2mm criterion. However, the brain exhibited slightly larger discrepancies, with an average deviation of 0.88. The head & neck, oesophagus, stomach, colon, lung, prostate, cervical, and breast showed progressively increasing average deviations, ranging from 1.04 to 4.76.

CONCLUSION: The results obtained from this study highlight the importance of site-specific optimization and rigorous QA protocols in radiation therapy. By identifying the treatment sites with larger discrepancies, improvements can be made in treatment planning, delivery techniques, and dose calculation algorithms to enhance treatment accuracy and patient safety. Further investigations are warranted to explore the underlying factors contributing to the observed variations and devise strategies to mitigate them effectively.

KEYWORDS: Patient-specific QA, portal dosimetry, Treatment Site, Dosimetric performance, Radiation therapy.

I. INTRODUCTION:

Accurate delivery of radiation dose is a critical component of radiation therapy for cancer treatment. Patient-specific QA[1] [2] plays a vital role in verifying the treatment plan's accuracy and ensuring that the planned dose is delivered as intended[3]. Portal dosimetry is a widely used technique for QA, providing a practical and efficient means of verifying dose distributions during treatment delivery[4]. This study aims to evaluate the dosimetric performance of different treatment sites using portal dosimetry and compare the results across various criteria.

Radiation therapy plays a crucial role in cancer treatment, aiming to deliver an accurate and precise radiation dose to the tumour while minimizing the impact on healthy tissues. To ensure the quality and effectiveness of radiation therapy, patient-specific quality assurance (QA)[5] is essential. In this study, the researchers performed patient-specific QA for volumetric-modulated arc therapy (VMAT) plans using portal dosimetry[6]. The study focused on patients with various treatment sites and aimed to evaluate the accuracy and effectiveness of the treatment plans.

The findings of this study provide valuable insights into the dosimetric performance across different treatment sites. By analysing the data obtained at three different criteria, the researchers were able to assess the agreement between measured and calculated dose distributions and quantify any discrepancies. This evaluation of dosimetric performance can contribute to optimizing treatment protocols and improving patient outcomes.

II. MATERIALS AND METHODS:

Figure 1. True beam STx Linear accelerator with EPID

This study aimed to perform patient-specific quality assurance (QA) for VMAT plans using portal dosimetry and evaluate the dosimetric performance across different treatment sites. The study design involved a retrospective analysis of patient-specific QA data obtained at our institution. The treatment planning system used for VMAT planning was Eclipse with AAA algorithm[7] and heterogeneity correction was applied[8] .

Fifteen patients were randomly selected for each treatment site included in the study. The study encompassed various treatment sites, such as the liver, pancreas, brain, head & neck, oesophagus, stomach, colon, lung, prostate, cervical, and breast.

The VMAT treatment plans were generated using the Eclipse planning system[9]. The plans were designed to deliver the prescribed radiation dose to the target volume while minimizing the dose to surrounding healthy tissues. The treatment plans were optimized based on established clinical protocols and guidelines.

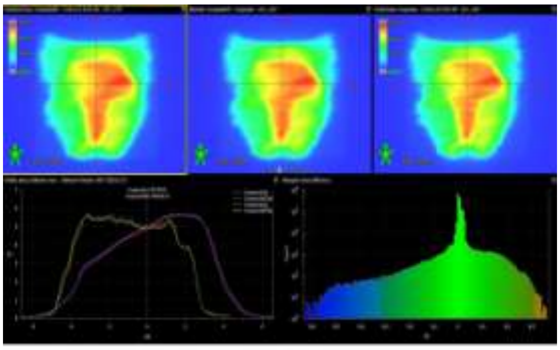

Figure2. Portal dosimetry Analysis

Patient-specific QA was performed on a True Beam STx linear accelerator equipped with an aS1200 electronic portal imaging device (EPID)[10]. The EPID was used for portal dosimetry measurements. The QA measurements were conducted for each patient and treatment site included in the study[11].

To assess the agreement between the measured and calculated dose distributions, a gamma analysis was performed[12]. Three different gamma criteria were considered: 3%3mm, 3%2mm, and 2%2mm. The gamma analysis compared the portal dosimetry measurements to the treatment plan's calculated dose distributions[13].

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Table 1. Gamma passing percentage for various treatment sites with 3%3mm criteria

Site	Brain	Breast	Cervical	Colon	Oesophagus	Head & neck	Liver	Lung	Pancreas	Prostate	Stomach
Gamma passing percentage (3%3 mm)	100	95	99.3	97.9	99.7	98.6	99.9	100	99.8	99.3	99.9
	100	88.8	94.3	100	99.8	99	100	99.1	100	99.9	100
	99.8	95.7	97.3	99.1	99.1	98	99.4	99.6	100	99.2	98.5
	99.8	93.5	98.4	97	99.3	100	99.9	100	100	98.3	99.4
	99.9	95.6	100	98	98.7	99.2	99.8	94	99.8	94.5	98.2
	99.4	96.3	100	100	97.9	99	99.9	100	100	99.6	94.7
	100	98.3	99.5	99.1	98.5	99.5	99.8	100	99.3	99.7	97.3
	99.8	88.3	99.9	97.4	98.4	99.4	99.8	93.7	99.7	98.1	99.9
	99.6	95.7	94.4	99.3	98.5	99.9	99.4	99.9	100	99.9	97
	99.2	87.9	97.6	96.8	99.6	99.8	100	99.8	100	98.8	99
	99.9	92.5	98	95.9	99.9	99.7	99.4	100	99.8	100	97.1
	99.8	99.6	97.9	99.7	100	99.8	99.9	99.8	99.9	99.5	99.2
	100	85.8	96.9	96.8	98.9	98.7	100	99.8	99	97.9	98.5
	97.8	87.1	97.5	99.2	98.5	98.1	100	99.6	99.8	99.6	99.1
Mean	99.64	92.86	97.93	98.30	99.06	99.19	99.80	98.95	99.79	98.88	98.41
Standard deviation	0.58	4.48	1.85	1.35	0.67	0.65	0.23	2.18	0.30	1.44	1.47

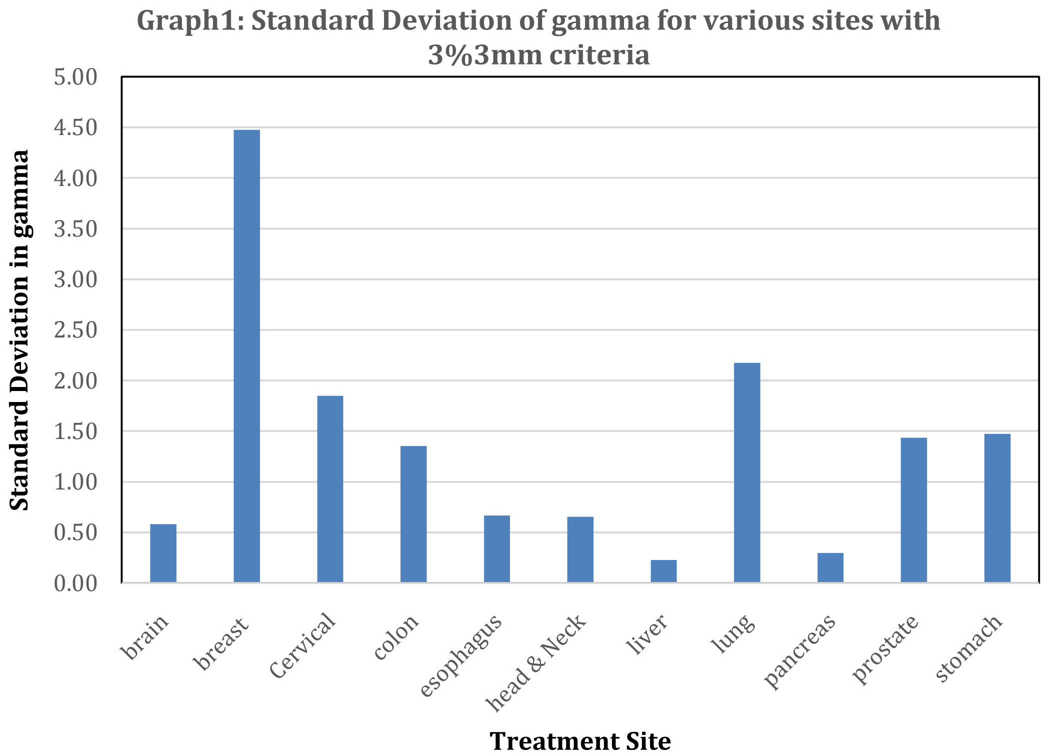

Table 2. Gamma passing percentage for various treatment sites with 3%2mm criteria

Site	Brain	Breast	Cervical	Colon	Oesophagus	Head & Neck	Liver	Lung	Pancreas	Prostate	Stomach
Gamma passing percentage (3%2mm)	100	94.9	98.9	97.1	99.6	98.5	99.9	100	99.8	98.9	99.9
	100	88.5	93.4	100	99.7	98.5	100	98.7	100	99.8	100
	99.7	95	97	98.4	98.6	97.2	99.2	99.3	100	98.6	98
	99.7	93.3	97	96.4	98.9	99.9	99.9	100	100	97.6	99.2
	99.9	95.4	99.9	96.9	98.2	98.7	99.8	92.6	99.7	93.7	97.9
	99.8	96.3	100	99.9	97.1	98.6	99.8	100	100	99.4	94.3
	100	97.8	99.2	98.6	98.4	99	99.8	100	99	99.5	96.5
	99.6	88.2	99.9	96.5	97.6	99.1	99.8	92.1	99.6	97.1	99.9
	99.4	94.9	92.7	98.9	98.4	99.8	99.3	99.8	100	99.9	96.2
	98.8	87.8	96.7	95.2	99.4	99.6	99.9	99.7	100	98.6	98.4
	99.9	88.7	97	95.7	99.8	99.7	99.2	100	99.6	100	96.5
	99.7	94.5	96.9	99.4	100	96.7	99.9	99.7	99.8	99.2	98.7
	100	85.6	95.8	95.4	98.6	98.1	99.9	99.8	98.7	97.1	98.5
	97.5	86.9	96.8	98.6	97.9	97.4	100	99.3	99.8	99.4	99.1
Mean	99.57	91.99	97.23	97.64	98.73	98.63	99.74	98.64	99.71	98.49	98.08
Standard deviation	0.68	4.11	2.26	1.67	0.88	1.00	0.28	2.69	0.40	1.69	1.67

Graph2: Standard Deviation of gamma for various sites with 3%2mm criteria

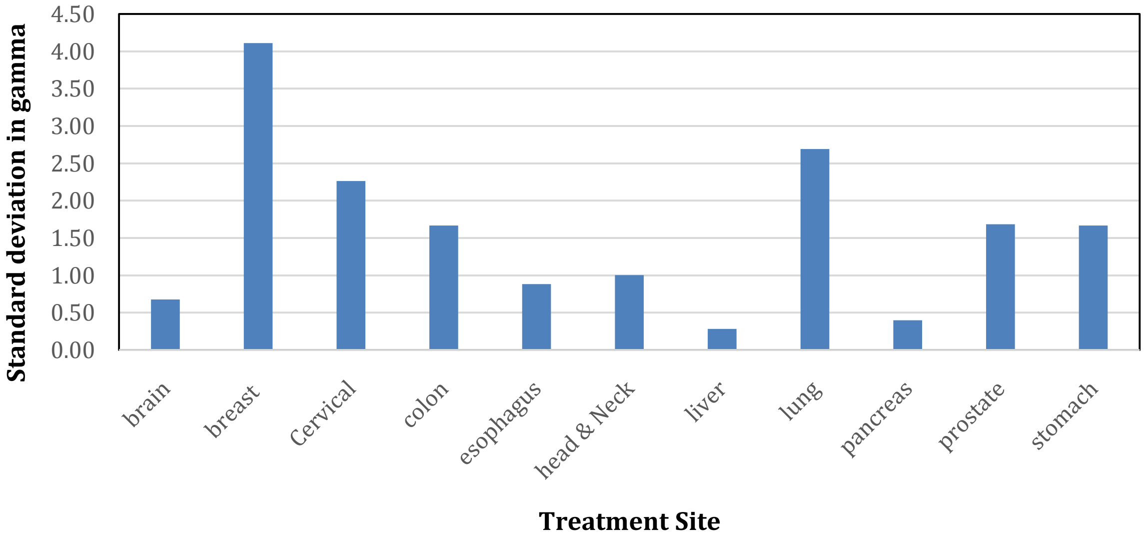

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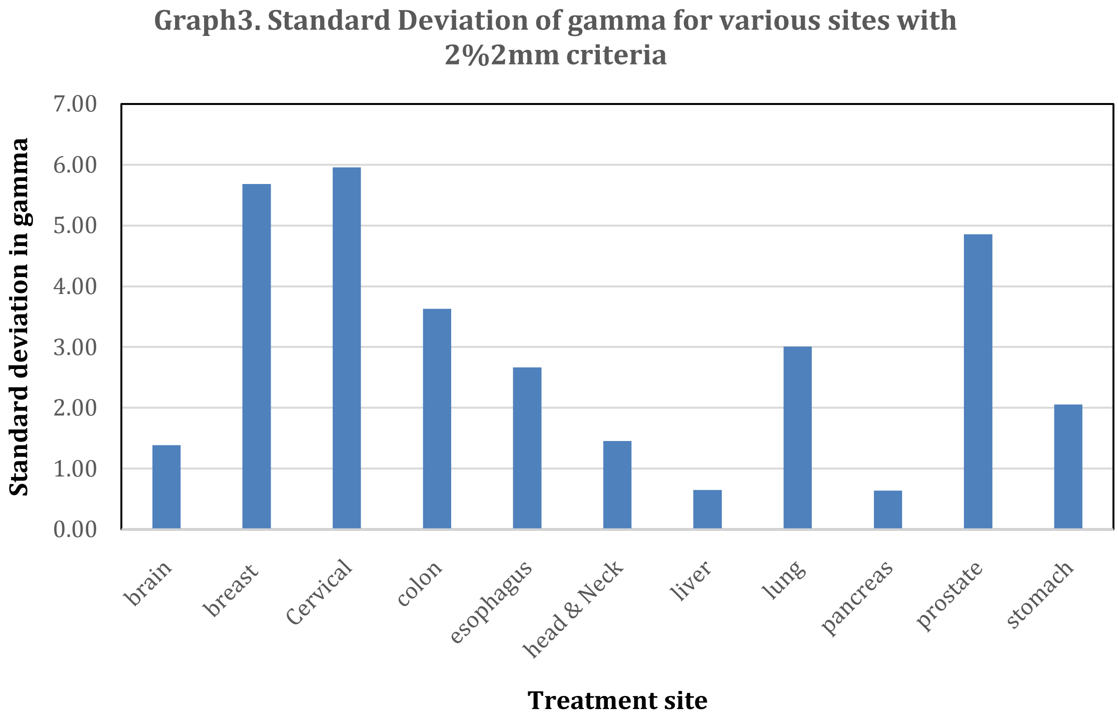
Table 3. Gamma passing percentage for various treatment sites with 2%2mm criteria

Site		Brain	Breast	Cervical	Colon	Oesophagus	Head & neck	Liver	Lung	Pancreas	Prostate	Stomach
Gamma passing percentage (2%2mm)		99.8	87.6	94.8	90.4	99.1	96.2	99.8	99.9	99.7	94.7	99.8
		100	79.8	79.5	100	99.1	96.2	99.9	96.9	100	99.6	100
		94.9	85.7	86.8	91.7	90	95.3	98.4	97	99.9	97.4	96
		99.1	81.7	95.6	94.4	97.6	99.7	99.8	100	99.9	96.3	98.8
		99.5	87.4	99.8	94.4	97.4	96	99.5	90.9	99	80.9	97
		99.1	89.3	99.9	99.7	96.1	97.1	99.6	100	99.9	98.9	93.1
		100	93.4	98.2	97.1	94.7	98.3	99.5	99.9	98.4	99.1	95.7
		99.4	83.3	99.7	91.9	96.7	95.4	99.6	91.9	98.8	95.7	98.8
		98.7	94	86.8	96.8	94.7	97	97.9	99.5	99.9	99.6	95.2
		98.2	82.7	95.2	92.6	94	99.3	99.1	99.6	99.9	97.8	96
		99.8	79.6	93.5	87.9	99.4	99.4	98.5	99.9	99.2	100	95.5
		99.3	91	95.6	97.3	99.8	96.8	99.8	99.3	99.6	98.8	98.2
		100	80.6	94.8	91.5	98	97.2	99.8	99.4	98	95.5	98.5
		97.4	97	89.1	97	97.3	96.6	100	98.7	99.3	99.2	99.1
Mean		98.94	86.65	93.52	94.48	96.71	97.18	99.37	98.06	99.39	96.68	97.26
Standard deviation		1.38	5.68	5.96	3.63	2.66	1.46	0.65	3.01	0.64	4.86	2.05



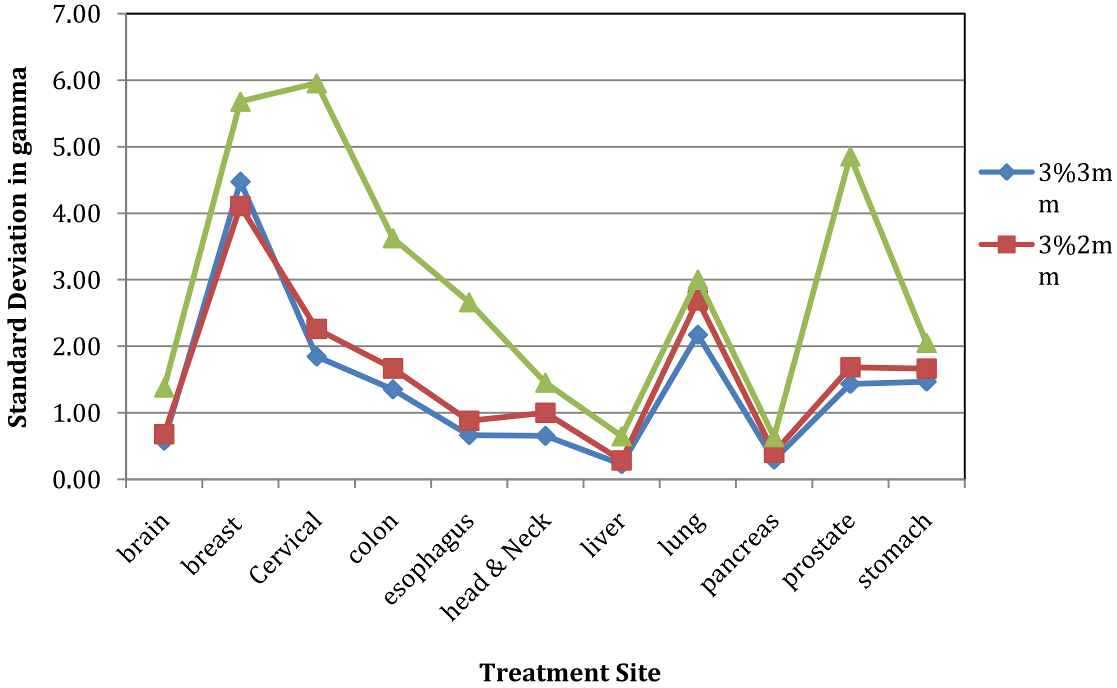
III. DATA ANALYSIS:

The obtained data were analysed to evaluate the dosimetric performance across different treatment sites and criteria. The average agreement between the measured and calculated dose distributions was computed for each treatment site and criterion. The deviations were quantified to identify any discrepancies and variations in dosimetric performance.

Table 4.Standard deviation of gamma percentage for various sites with different passing criteria

Site	3%3mm	3%2mm	2%2mm	Average
Brain	0.58	0.68	1.38	0.88
Breast	4.48	4.11	5.68	4.76
Cervical	1.85	2.26	5.96	3.36
Colon	1.35	1.67	3.63	2.22
Esophagus	0.67	0.88	2.66	1.40
Head & neck	0.65	1.00	1.46	1.04
Liver	0.23	0.28	0.65	0.39
Lung	2.18	2.69	3.01	2.63
Pancreas	0.30	0.40	0.64	0.44
Prostate	1.44	1.69	4.86	2.66
Stomach	1.47	1.67	2.05	1.73

Graph4. Standard Deviation of gamma for various sites



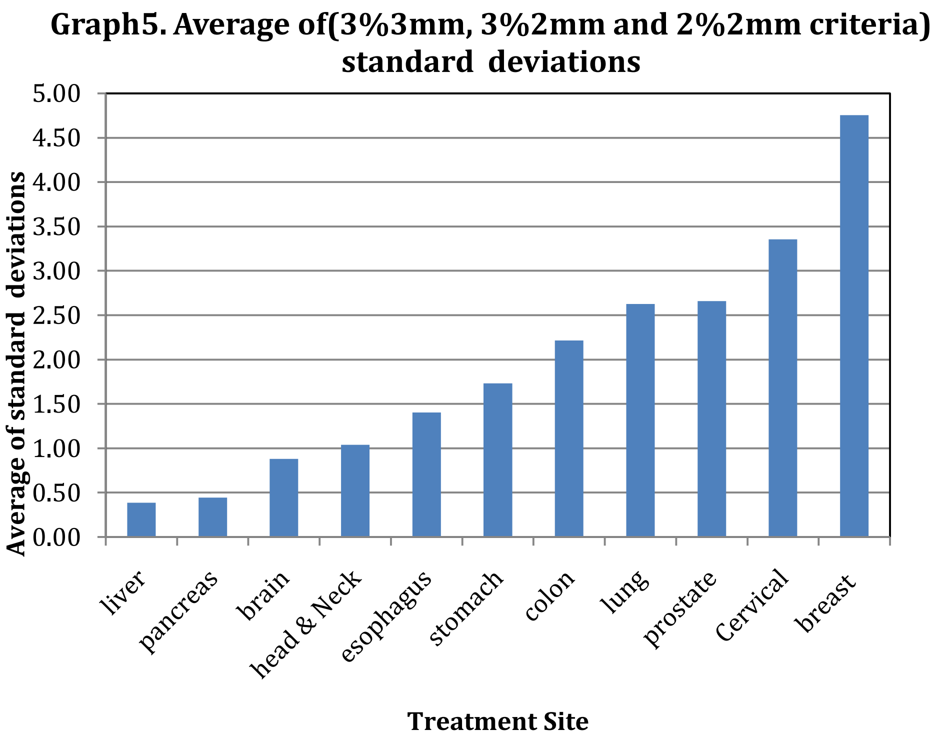
IV. STATISTICAL ANALYSIS:

Descriptive statistics, such as mean and standard deviation, were calculated for the average deviations obtained from the gamma analysis. The deviations were analysed to assess the variations in dosimetric performance across different treatment sites and criteria.

International Journal Dental and Medical Sciences Research
Volume 5, Issue 4, July-Aug 2023 pp 578-586 www.ijdmsrjournal.com ISSN: 2582-6018

Table5. Average of(3%3mm, 3%2mm and 2%2mm criteria) standard deviations

Site	Average SD
Liver	0.39
Pancreas	0.44
Brain	0.88
Head & neck	1.04
Esophagus	1.40
Stomach	1.73
Colon	2.22
Lung	2.63
Prostate	2.66
Cervical	3.36
Breast	4.76



V. RESULTS:

The liver and pancreas exhibit the lowest average standard deviations, indicating a relatively low variation in gamma values. This suggests consistent and stable treatment outcomes for these sites.

The brain, head & neck, oesophagus, and stomach show moderate average standard deviations, suggesting a moderate level of variation in gamma values.

The colon, lung, prostate, cervical, and breast have higher average standard deviations, indicating a higher level of variation in gamma values. This suggests that the treatment plans and radiation delivery for these sites may need more attention to achieve consistent results.

VI. DISCUSSION:

The observed variations in Dosimetric performance among different treatment sites can be attributed to several factors, including the complexity of the anatomy, proximity to critical structures, and treatment techniques employed. The liver and pancreas, being relatively simpler treatment sites, showed better agreement between measured and calculated dose distributions. On the other hand, treatment sites such as breast and cervical exhibited larger discrepancies, which might be influenced by the presence of complex anatomical structures and the use of advanced treatment modalities.

VII. CONCLUSION:

Based on the analysis, it can be concluded that different treatment sites have varying levels of variation in gamma analysis. The liver and pancreas exhibit relatively low variation, indicating more consistent treatment outcomes. However, the breast site shows the highest level of variation, suggesting challenges in delivering radiation treatment consistently.

These findings highlight the importance of evaluating and optimizing radiation treatment plans for each specific site to minimize variations in gamma values and improve treatment accuracy and consistency. Further research and improvements can be focused on sites with higher variation to ensure more uniform treatment outcomes across all sites.

ACKNOWLEDGMENTS:

We would like to express gratitude to our Chairman, Dr D Nageshwar Reddy, and the management of AIG Hospitals, Gachibowli, Hyderabad, for giving us the opportunity to perform this study.

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