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Comparison of Quality Assurance of Three Different CT Scanner Models: A Five-Year Study

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Abstract

This study focused on analysing the effectiveness of some CT scanner models; in this concern, this selected Siemens Medical CT Scanner, Philip CT Scanner, and GE Discovery STE. This study gathered from the periodic quality assurance primary data done once in two years, on the CT scan machines. This report presented the phantom scanning report for over five years, which allowed a comparative study among these three machines for slice thickness, accuracy of operating potential and accuracy of timer . This study found that all the CT Scanners to are consistent in the performance of the scanning and they are well within the limits set by the regulatory body.

Keywords: CT Scanner models, Quality Assurance

Introduction

CT scanning increased its popularity as this combines X-ray through computerised technology and takes images of the whole body from different angles. Siemens Medical CT Scanner, Philip CT Scanner, and GE Discovery STE are three different CT scanners that adequately provide CT scanner reports to an individual (Pourvaziri*et al.* 2022). Through these scanners, an individual can assess their health conditions with the help of images; doctors can treat their patients according to their health conditions.

Aim and objectives

This study is going to compare and analyse the effectiveness of three scanner models and their quality assurance.

The objectives of this study are:

- To assess the use of three different models
- To evaluate the effectiveness of results by using these models
- To conduct a comparison of these three CT scanner models of five years

Siemens Medical CT Scanner is used with a Somatom Emotion; this requires a 70 cm gantry aperture and a 50 cm scan field. Philip CT Scanner is also named with Phillips Brilliance Big Bore configuration; its configuration is with 85 cm diameter and a scan field of 60 sm. This has the advantage of sub-second imaging up to 0.4 seconds along with a 24 mm volumetric coverage. On the other hand, GE Discovery STE acts as a discovery dimension console which has a 70 cm field for full display with the highest sensitive view. GE Discovery STE provides 16 slice configurations with the acquisition of 2D, 3D and 4D, while the high-performance system of 16 slice configurations of Philip CT Scanner provides the acquisition of 3D and 4D CT.

Literature review

Computerized Tomography (CT) is used for combining a sequence of X-ray images that are taken from various angles around a body. A CT scanner uses computer processing to form cross-sectional images of bones, blood vessels and other body parts. The CT scanners are used for analyzing the internal injury of a body. The scanner is used to visualize all aspects of the body and diagnose any disease or damage in the body.

Siemens Medical CT scanner model

The geometry of the Siemens CT scanner model has been designed by taking the X-ray spectrum, detector system and collimator into consideration. The quality assurance models were created for this scanner to analyse the imaging aspects of simulation. The projected simulated data has been processed using MATLAB software to reconstruct the image taken using the X-ray spectrum (Vavřík*et al.*, 2023). One of the critical elements required in the simulation of the X-ray source is accurately representing the energy spectrum of X-rays.

Philips CT scanner model

The model of the Philips CT scanner is advanced in nature, and it has been used in China to collect images. The convolutional-based neural network has been used in the analysis of the Philips CT scanner model, which helps in improving the quality of the CT scanner (Hille *et al.*, 2023). The convolutional neural network has been used for denoising the images after performing the CT scan. There are 13 layers present in the convolutional neural network to analyse the difference between the input image and the denoised image. A projection domain has been used in the CT scanner to improve the robustness of one of the common problems, which is the slightest square problem.

GE Discovery STE model

Discovery STE is a scanner that is used to generate images in 2-dimensional and 3-dimensional modes. This type of scanner is used in the field of advanced cardiology and oncological studies. The discovery of this scanner began with a vision to shape the present healthcare system in good form (Rojulpote*et al.*, 2020). The scanner provides quality assurance and is used for effective treatments relevant to individual patients. The sensitivity rate is of the highest level when compared to the other scanners in the market. The scan time required for this scanner is high with high resolution. Moreover, the scan report can be easily accessed on mobile. The quality assurance of this model is dependent on sensitivity.

Method

Variables

Independent variables

Quality of results of three CT scanner models, which are Siemens Medical CT Scanner, Philip CT Scanner, and GE Discovery STE

Dependent variables

Quality assurance from these three machines.

Data collection

Necessary information in this study is gathered from the reports developed from the three selected CT scanning models. This is the primary source of information with the personal information of the participant; this report contains a report of 5 years of the same patient.

Data analysis

This study conducted a qualitative analysis of the gathered data from the CT scan reports. This assisted this research process in analysing the information and effectiveness of the reports. Pomerantsev and Rodionova (2021) mentioned that qualitative analysis conducts an in-depth analysis. Through an in-depth analysis, this analysis method efficiently developed a comparison among these scanning models.

Ethical consideration

The personal information of the participant is not revealed in this study; furthermore, the participant willingly provided her report.

Data Analysis and Discussion

Results

Sr. No.	Parameters Tested	Specific Values	Measured Values	Tolerance	Result
A1	Alignment of Table to Gantry	0 mm	Deviation is 0 mm	±5 mm	**Passed**
A2	Accuracy of Gantry Tilt	+15°	+15°	±2°	**Passed**
		-15°	-15°		
A3	Table Indexing Accuracy	40 mm	40 mm	± 1 mm	**Passed**

Figure 1: The summary of mechanical safety performance test report of Philip CT Scanner

(Source: CT Scan report 1)

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This report presents the way Philip CT Scanner conducted the CT scan of the patient in 2023. Figure 1 highlights the way table of gantry is aligned, gantry tilt is accurate, and the table index is accurate. The machine passed its safety report as the table of gantry has deviation of 0 mm, and tolerance of +/-5 mm. furthermore, gantry tilt is also between (+15°) and (-15°), which is +/-2°. In addition, its measured value and specific value of 40 mm also passed its mechanical safety.

Sr. No.	Parameters tested	Specific values	Measured values	Tolerance		Remarks
1.	Slice thickness (mm)	0.625 1.25 5	1 1 5	For slice thickness a. Less than 1 mm b. 1 mm to 2 mm c. Above 2 mm	0.5 mm ± 50% ±1 mm	Pass
2.	Accuracy of Operating Potential (kV)	(last value maximum kV)		±2 kV		Pass
		120	119.93			
		140	139.67			
3.	Accuracy of Timer	1	1.010	% Error< 10 %		Pass
		2	2.010			
		3	3.011			

Figure 2: The summary of mechanical safety performance test report for GE Discovery STE

(Source: CT Scan report2)

Figure 2 highlights that GE Discovery STE passed in its slice thickness test, accuracy of timer, and operating potential accuracy. Its specific values for slice thickness of 0.625, 1.25, and 5 allowed this model to pass. Again, specific value of accuracy of operating potential of 120 kV and 140 kV passed this model to increase its safety condition. Moreover, error was less than 10% for the tolerance of accuracy of timer that is also good for this model.

Sr No.	Parameters Tested	Specific Values	Measured Values	Tolerance For Slice Thickness		Remark
1	Slice Thickness (mm)	2.0 mm 5.0 mm 10 mm	2.44 mm 5.39 mm 10.3 mm	a. <1.0 mm b. (1.0-2.0) mm c. Above 2.0 mm	0.5 mm ± 50% ± 1.0 mm	Pass
2	Accuracy of Operating Potential (kV)	At 130 kV	128.6 kV	± 2 kV		Pass
3	Accuracy of Timer	At 0.80 Sec	0.805 Sec	%Error < 10%		Pass

Figure 3: The summary of mechanical safety performance test report for Somatom Siemens medical CT scanner

(Source: CT Scan report 3)

Figure 3 mentions the way Somatom Siemens 4 slice or Siemens Medical CT Scanner also passed in passed with its specific value of 2.0 mm, 5.00 mm, and 10mm in slice thickness. Furthermore, its accuracy operating potential is passed at 130kV of specific value and 128.6 kV of measured value. This CT scanner model also has error less than 10% like GE Discovery STE model; hence, this model is also good and safe for patients.

Sr. No.	Parameters Tested	Specific Values	Measured Values	Tolerance	Result
1	Slice thickness (mm)	0.75 mm 1.5 mm 3 mm	1.05 mm 1.85 mm 3.15 mm	a. Less than 1 mm: 0.5 mm b. 1 mm to 2 mm: ± 50% b. Above 2 mm: ±1 mm	**Passed**
2	Accuracy of Operating Potential (kV)	80 kV 120 kV 140 kV	80.41 kV 120.75 kV 140.74 kV	±2 kV	**Passed**
3	Accuracy of Timer	0.75 s 1 s 1.5 s	0.768 s 1.054 s 1.552 s	% Error< 10 %	**Passed**

Figure 4: The summary of mechanical safety performance test report for Somatom Siemens medical CT scanner

(Source: CT Scan report 4)

Figure 4 implies that the slice thickness in case of Philips CT scanner is well within the permissible limits and as well pass the result. Operating potential is checked for three different kV and all are less than 1kV. Accuracy of timer is well within the tolerance limits of less than 10%.

Model of scanner	Parameter tested	2017	2019	2021
PhilipsBig Bore	1. Slice thickness 2. Accuracy of time 3. Accuracy of operating potential 4. Reproducibility of output (CoV)	<.2mm <.013sec <1kV .001	<.2mm <.05sec <1kV .0023	<.3mm <.05sec <2kV .003
GE discovery	1. Slice thickness 2. Accuracy of time 3. Accuracy of operating potential 4. Reproducibility of output (CoV)	2mm <.05sec <-0.3kV .002	.4mm <.05sec <-0.4kV .001	.3mm <.05sec <-0.33kV .003
Siemens somatom	1. Slice thickness 2. Accuracy of time 3. Accuracy of operating potential 4. Reproducibility of output (CoV)	<.5mm <.05sec <-1kV .001	<.5mm <.05sec <-2kV .002	<.5mm <.05sec <-1.5kV .002

Figure 5: The summary performance test report for Philips, GE discovery STE and Siemens Somatom medical CT scanner

Figure 5 provides us the overall performance of three CT scanners done in 5 years of time.

Analysis and discussion

Philip CT Scanner has slice thicknesses of 1x1 mm, 2x2 mm, 3x3 mm, 4x4 mm, and 5x5 mm and FOV measurements of 125 mm and 500 mm. The slice thickness can differ in the quality of the results in a report; in addition, this scanner has a stronger noise reduction technique. This noise reduction technique reduces the reliability of Philip's CT Scanner; hence, it can be said that the CT scanner models should not use any noise reduction strategy (Varghese *et al.* 2019). The CTTA metrics are highly effective for the development of a proper scanning report.

A full scanner simulator is based on the GATE toolkit, and a Monte Carlo simulation has been performed for developing SPECT studies. This package is designed for simulating the PET systems that help to provide the ability to characterize the effects of non-collinearity and the patient motion onto the resolution of PET images. It is considered as open-source information for identifying the ROOT objects in the data analysis framework. As the new features becomes available in the market, they can be linked easily to the GATE by using simple shape combinations (Wu *et al.* 2021). The limitations of the software is therefore based on the design of photon interactions based on real scanner detection and the electronics parts present in Discovery GE. The module of digitizer mimics helps in separating the portion of signal processing chain (Kalaitzidis *et al.* 2022). Crystal QE, therefore, makes the electronic delay so that is can be defined within the module. Limitations of the software with regard to complex shapes can be simulated by utilizing the technology of block designs. The data processing system present within GATE helps enable signal processing chains so that an accurate PET scanner can be enabled. It could be accomplished with the help of a signal processing routine so that the chain can be simulated. The result Monte Carlo package was validated for performing the overall robustness check so that axial sensitivity could be detected (Karakatsanis *et al.* 2022). Due to having limited space, the results have been validated by the comparison of NU01 measurement of CT scanners. Radiation exposure has been determined by using ten axial sections that have a thickness of 2.5 cm. This helps in positioning the CBCT system so that visualization can be enabled, including the mandibular condyles. The dosimetry values have been determined, and the correction factors for energy sensibility measurement.

Conclusion

From the above study, it can be concluded that a prototype CT Scanner has been designed that undergoes several clinical evaluations. It helps in performing whole-body scans for the quantitative measurement over an axial range of 100 cm by using attenuation correlation. The clinical results obtained suggests that a wider range of human cancer could be obtained by the help of CT scanners. Acquisition of the functional and anatomical images could be scanned conveniently onto the patients for the purpose of simplifying patient transfer effectively. The combined approach of PET/CT can be achieved by offering diagnostic improvements and the identification of disseminated disease. It can be improved further by using radio-treatment therapy and monitoring chemotherapy tests in detail. Results obtained from this prototype could be described for the purpose of demonstrating feasibility of different images during the single scanning session. It will help in both single scanning and to acquire two modalities in a separate method. Effectiveness of this CT imaging could be illustrated by the help of clinical cases that have been selected as an isodose mass and provides effective information to active the tumor regions. It will help to develop a better diagnostic practice so that critical patients can be treated more accurately.

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