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Evaluation Of CT Image Quality Based On Signal-To-Noise Ratio In Axial And Helical Scanning Modes With Tube Current Variation

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Abstract: This study aims to evaluate computed tomography (CT) image quality based on the signal-to-noise ratio (SNR) parameter across two scanning modes: axial and helical. An anthropomorphic head phantom was scanned using a Siemens Healthineers Somatom go.Top CT system. The evaluation was conducted using tube current variations of 100 mAs, 200 mAs, and 300 mAs for each scanning mode. This approach was employed to investigate the influence of tube current variation on image quality and to identify the optimal parameter combination that yields the highest image quality. The results demonstrated a consistent increase in SNR with rising tube current for both scanning modes. However, the helical mode tended to produce higher SNR values compared to the axial mode at equivalent tube currents. These findings suggest that the helical mode is superior in producing better-quality images in terms of SNR. This study may serve as a reference for selecting technical imaging parameters to achieve optimal CT image quality. The conclusion indicates that the helical mode at 300 mAs provided the highest image quality, with the highest SNR value of 4.79 and the lowest noise level of 4.43 HU. Nonetheless, it should be noted that higher tube current also leads to increased radiation dose, thus clinical application should be tailored according to patient-specific needs.

Keywords: CT scan, signal-to-noise ratio, image quality, axial mode, helical mode, tube current.

I. INTRODUCTION

Computed Tomography (CT) is one of the most widely utilized diagnostic imaging modalities in clinical practice due to its ability to produce detailed and high-resolution cross-sectional images of the human body [1]. In practice, CT image quality is greatly influenced by several technical parameters, among which tube current (mAs) and the selected scanning mode axial or helical play crucial roles [2]. Tube current directly affects the number of X-ray photons emitted by the X-ray tube, thereby influencing the noise level and visual quality of the resulting image [3]. Generally, increasing the tube current enhances the signal-to-noise ratio (SNR); however, it also proportionally increases the radiation dose absorbed by the patient [4]. Therefore, tube current adjustment should balance between sufficient image quality and adherence to radiation protection principles, particularly the ALARA (As Low As Reasonably Achievable) principle [5].

Axial and helical scanning modes differ fundamentally in data acquisition methods. Axial scanning acquires data slice-by-slice in a stepwise manner, whereas helical scanning employs a continuous spiral motion, allowing for faster and more consistent data acquisition [6]. Several studies have indicated that the helical mode tends to yield higher SNR values compared to the axial

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mode, particularly at the same tube current settings [7],[8]. This may be attributed to improved detection efficiency and data accumulation in helical scanning.

The signal to noise ratio (SNR) is a key quantitative metric used to evaluate image quality in medical imaging, as it reflects the extent to which anatomical signal can be distinguished from statistical noise [9]. A higher SNR value indicates superior image quality, thereby supporting more accurate clinical diagnoses. In the context of enhancing radiology service quality and diagnostic efficiency, it is essential to assess the relationship between tube current variation and scanning mode in terms of their effect on SNR. This study aims to evaluate CT image quality based on SNR in both axial and helical scanning modes using tube current settings of 100 mAs, 200 mAs, and 300 mAs. The scans were conducted using an anthropomorphic head phantom designed to approximate the density characteristics of human tissue. The findings are expected to contribute to the optimization of imaging protocols in clinical radiology practice.

II. Experimental Procedure

Image acquisition was performed using a Siemens Healthineers Somatom go.Top CT scanner. An anthropomorphic head phantom was scanned in both axial and helical modes. The scanning parameters are presented in Table 1.

Table 1. CT Scan input Parameters

No	Parameters	Value
1	Mode	Helical and axial
2	kV	130
3	mAs	100,200,300
4	Slice Thickness	1mm
5	Length Scan	17,30 cm
6	Pitch	0,65

The positioning of the phantom during the CT scan acquisition is illustrated in Figure 1. The phantom was aligned on the scanner table according to the manufacturer's guidelines and positioned at the scanner’s isocenter to ensure accurate and reproducible image capture.

Figure 1. Phantom positioning during CT scan acquisition

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Image quality was evaluated by placing circular Regions of Interest (ROIs) within the eye lens region of the phantom. The ROI placement is illustrated in Figure 2 for the axial scan images and Figure 3 for the helical scan images. These measurements were used to determine the CT number (in Hounsfield Units) and image noise level (HU). The signal-to-noise ratio (SNR) was then calculated using Equation (1):

$$SNR = \frac{signal}{noise} \quad (1)$$

III.RESULTS AND DISCUSSION

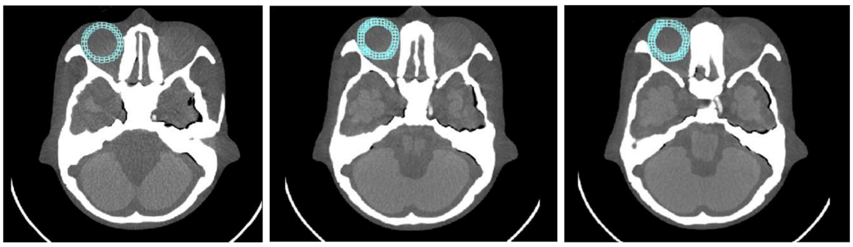
This study evaluates the image quality of computed tomography (CT) by comparing axial and helical scanning modes through an analysis of the signal-to-noise ratio (SNR) across varying tube current (mAs) levels. All scans were conducted using an anthropomorphic head phantom with fixed technical parameters: 130 kV, 1 mm slice thickness, and a pitch of 0.65. The evaluation focused on how SNR changes in response to tube current variations in each scanning mode and the influence of acquisition mode on image quality.

The assessment of image quality in head CT examinations in this study was conducted by analyzing the parameters of signal (HU), noise (HU), and Signal-to-Noise Ratio (SNR). The measurements presented in Table 2 demonstrate a consistent relationship between increased tube current (mAs) and improved image quality in both axial and helical scanning modes.

Table 2. Signal and noise values of axial and helical images at varying mAs levels

Scanning Mode	mAs	Signal (HU)	Noise (HU)	SNR
Axial	**100**	24,49	12,08	2,03
	200	22,53	8,78	2,57
	300	30,73	7,55	4,07
Helical	**100**	19,44	7,19	2,7
	200	25,62	6,14	4,17
	300	21,23	4,43	4,79

As presented in Table 2, there was a consistent improvement in image quality with increasing mAs in both scanning modes. In axial mode, increasing the tube current from 100 to 300 mAs resulted in a progressive rise in SNR from 2.03 to 4.07. Specifically, SNR increased by approximately 26.6% between 100 and 200 mAs, and by 58.4% from 200 to 300 mAs. These results confirm a significant enhancement in image quality, consistent with previous findings indicating that higher mAs reduces image noise and improves diagnostic confidence [10], [11].



(a) (b) (c)

Figure 2. Axial scan images at (a) 100 mAs, (b) 200 mAs, and (c) 300 mAs

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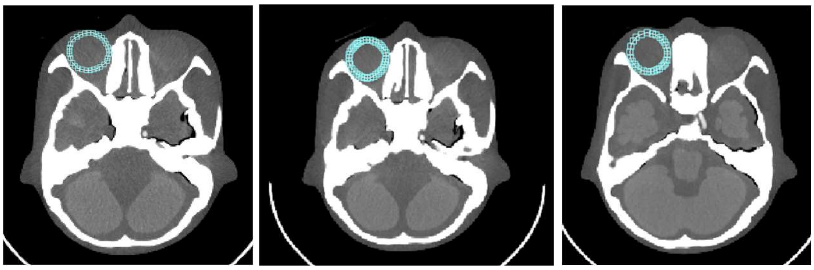

(a) (b) (c)

Figure 3. Helical scan images at (a) 100 mAs, (b) 200 mAs, and (c) 300 mAs

Helical mode also demonstrated an upward trend in SNR with increased mAs, but with a distinct pattern. SNR improved from 2.70 at 100 mAs to 4.17 at 200 mAs (a 54.4% increase), and then to 4.79 at 300 mAs (a 14.9% increase). This indicates that in helical scanning, the majority of image quality improvements occur at mid-range dose levels, with diminishing returns at higher doses.

A comparative graph of axial and helical SNR values is presented in Figure 4. Across all mAs levels, the helical mode consistently produced higher SNR values than the axial mode. The continuous acquisition nature of helical scanning allows for more efficient data collection and signal averaging, resulting in lower image noise and improved SNR. Prior studies have supported these findings, particularly when pitch and detector settings are optimized [12].

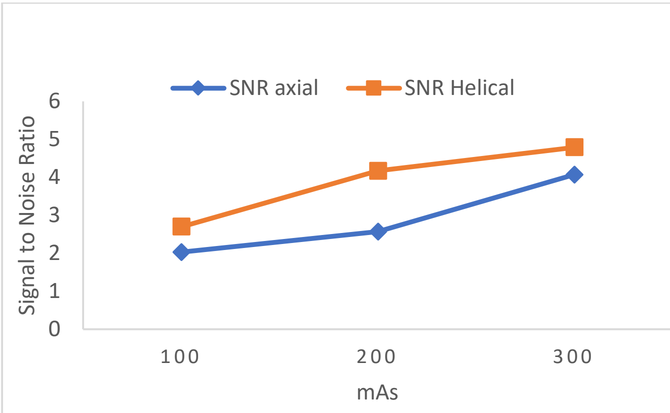

Figure 4. Comparison of SNR values in axial and helical modes

However, increasing the tube current also leads to higher radiation exposure. Therefore, the selection of optimal mAs parameters must balance diagnostic requirements with patient safety. The ALARA (As Low As Reasonably Achievable) principle remains a central guideline in scan protocol design. Advanced technologies such as iterative reconstruction can further support the achievement of high SNR at lower mAs settings, enabling high-quality images with minimal radiation dose [13], [14].

Based on the findings of this study, the helical scanning mode at 300 mAs produced the best image quality, achieving an SNR of 4.79 with the lowest recorded noise value (4.43 HU). While this indicates a clear technical advantage, clinical decision-making must always weigh the benefits of superior image quality against the potential risks of increased radiation exposure. Therefore, individualized protocols based on patient size, clinical indication, and diagnostic requirements remain essential for optimal practice.

IV. CONCLUSION

The Signal to Noise Ratio (SNR) of CT scan images of an anthropomorphic phantom was successfully evaluated using both axial and helical scanning modes. An increase in tube current resulted in a corresponding increase in the SNR. The helical scanning mode yielded higher SNR values compared to the axial mode at equivalent mAs levels. The highest SNR value, 4.79, and the lowest noise level, 4.43, were obtained using the helical mode at a tube current of 300 mAs. These findings suggest that the helical scanning mode provides superior image quality in CT imaging.

REFERENCES

[1] Bushberg, J. T., Seibert, J. A., Leidholdt, E. M., & Boone, J. M. (2012). *The Essential Physics of Medical Imaging*. Lippincott Williams & Wilkins.

[2] Kalender, W. A. (2011). *Computed Tomography: Fundamentals, System Technology, Image Quality, Applications*. Wiley-VCH.

[3] McCollough, C. H., Primak, A. N., Braun, N., Kofler, J., Yu, L., & Christner, J. (2009). Strategies for reducing radiation dose in CT. *Radiologic Clinics of North America*, 47(1), 27–40.

[4] Crawford, C. R., & King, K. F. (2013). *Computed Tomography: Principles, Design, Artifacts, and Recent Advances*. SPIE Press.

[5] ICRP. (2007). *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103.

[6] Goldman, L. W. (2007). Principles of CT and CT technology. *Journal of Nuclear Medicine Technology*, 35(3), 115–128.

[7] Riyanto, A., Sumarna, D., & Pranoto, H. (2019). The Effect of mAs Variation on Noise and Low-Contrast Resolution in CT Scan Imaging. Berkala Fisika, 22(2), 92–98.

[8] Herlinda, H., Wibisono, G., & Yuniarti, N. (2019). The Effect of Tube Voltage and Current Variation on Noise and Uniformity in CT Imaging. JPOSITRON, 9(2), 65–70.

[9] Seeram, E. (2015). *Computed Tomography: Physical Principles, Clinical Applications, and Quality Control*. Elsevier Health Sciences.

[10] Silva, A. C., Lawder, H. J., Hara, A., Kujak, J., & Pavlicek, W. (2010). Innovations in CT dose reduction strategy: Application of the adaptive statistical iterative reconstruction algorithm. *American Journal of Roentgenology*, 194(1), 191–199.

[11] Leipsic, J., LaBounty, T. M., Heilbron, B., Min, J. K., Mancini, G. J., Lin, F. Y., Taylor, C., Dunning, A., & Earls, J. P. (2010). Adaptive statistical iterative reconstruction: Assessment of image noise and image quality in coronary CT angiography. *American Journal of Roentgenology*, 195(3), 649–654.

[12] Mori, S., Endo, M., Nishizawa, K., Tsunoo, T., Miyazaki, H., & Fujiwara, H. (2005). Physical performance comparison between axial and helical scan modes in multislice CT. *Medical Physics*, 32(5), 1500–1507.

[13] Willemink, M. J., & Noël, P. B. (2019). The evolution of image reconstruction for CT—from filtered back projection to artificial intelligence. *European Radiology*, 29(5), 2185–2195.

[14] Solomon, J., Mileto, A., Ramirez-Giraldo, J. C., & Samei, E. (2015). Diagnostic performance of an advanced modeled iterative reconstruction algorithm for low-contrast detectability with a third-generation dual-source multidetector CT scanner: Potential for radiation dose reduction in a multireader study. *Radiology*, 275(3), 735–745.