Fabrication of Gelatin-Based Phantom for Evaluating Computed Tomography (CT) Image Noise

Mark Anthony C. Burgonio[1], Jenna Rose G. Abenes[2], Janella Faye B. Camarillo[3] Adrielle Grace C. Magpali
Raenell-An G. Mariano[5] , Hazel Say G. Octaviano[6] , Ruth Ann O. Sanson[7] , Marites c. Pagdilao[8] , Gryn T. Salagma[9],
Ivy Rose C. Orozco[10], Joylyn P. Baniaga[11]

[1]College of Radiologic Technology, Lorma Colleges, markanthony.burgonio@lorma.edu,[2]College of Radiologic Technology, Lorma Colleges, jennarosejade@lorma.edu,[3]College of Radiologic Technology, Lorma Colleges, janellafaye.camarillo@lorma.edu,[4]College of Radiologic Technology, Lorma Colleges, adriellegrace.magpali@lorma.edu,[5] College of Radiologic Technology, Lorma Colleges, raenell-an.mariano@lorma.edu,[6]College of Radiologic Technology, Lorma Colleges, hazelsay.octaviano@lorma.edu,[7]College of Radiologic Technology, Lorma Colleges, ruthann.sanson@lorma.edu,[8]Research Institute, Lorma Colleges, marites.pagdialo@lorma.edu,[9]College of Radiologic Technology, Lorma Colleges, gryn.salagma@lorma.edu, [10]College of Pharmacy, Lorma Colleges, ivyrose.orozco@lorma.edu,[11]College of Inclusive Education, Lorma Colleges, joylyn.baniaga@lorma.edu

Abstract

This study aimed to fabricate a gelatin-based phantom and evaluate its effectiveness in assessing CT image noise compared with a commercially available phantom. A quantitative true experimental design was utilized, employing bovine gelatin and sucrose to create a tissue-equivalent phantom. The fabricated phantom was examined using regulated CT parameters, and image quality metrics including mean Hounsfield Unit (HU), standard deviation, signal-to-noise ratio (SNR), and noise power spectrum (NPS) were evaluated.

The results indicated that the fabricated phantom yielded consistent HU values and stable noise measurements, confirming its efficacy for dependable CT image assessment. In comparison to the commercial phantom, the fabricated phantom demonstrated marginally reduced image noise and revealed statistically significant differences ($p < 0.05$), suggesting disparities in material composition and imaging response. Despite these differences, the gelatin-based phantom proved to be as a realistic and economical substitute for CT quality assurance, especially in resource-constrained environments. The results indicate that locally constructed phantoms can facilitate imaging instruction, research, and initial quality control, while providing accessibility and flexibility for future enhancement.

Keywords: *Image noise, gelatin-based phantom, diagnostic performance, quality assurance, computed tomography, signal-to-noise ratio, noise power spectrum.*

1. Introduction

Computed Tomography (CT) paves the way for quicker assessment of patients' conditions and more accurate diagnostic decision-making. This exceptional imaging technology, advancing through continuous innovations since Alessandro Vallebona’s initial creation of tomography with radiographic film, owes its modern achievements to the groundbreaking work of Godfrey Hounsfield and Allan Cormack, who developed the first-generation CT scanners (ISCT, 2023).

Building on this historical foundation, Computed Tomography is a medical imaging method that uses X-rays to create detailed cross-sectional images of the body. It enables physicians to visualize internal structures without surgical intervention and is highly valuable for identifying diseases, injuries, and other health issues. CT scans can clearly show bones, organs, blood vessels, and soft tissues. They are frequently used in emergencies due to their speed and precision. For example, globally, South Korea conducted over 304 CT exams per 100,000 population in 2022, while the US reported about 255 (Statista, 2025). In the Philippines, the CT scan market reached ₱582 million in 2023 and is projected to grow to ₱1.02 billion by 2030 at an 8.37% CAGR, driven by rising chronic diseases such as cancer (the second leading cause of death at 13.5% of fatalities) and increasing demand in trauma cases, where 42.4% of patients receive cranial CTs. This growth underlines CT's role in addressing healthcare gaps in resource-limited settings like the Philippines.

A crucial factor determining CT image quality is image noise. According to Hassan (2023), increasing slice thickness leads to higher image noise levels, emphasizing the importance of selecting appropriate slice thickness in CT facilities to ensure diagnostic accuracy and enhance quality control. High-quality CT images exhibit low noise, resulting in clearer detail. Therefore, balancing noise and patient radiation dose is essential, since reducing noise often requires increasing radiation dose.

Noise in CT imaging refers to unwanted fluctuations in pixel values that create a grainy appearance and reduce image clarity. Recent research shows image noise decreases with thinner slice thickness; for instance, a slice thickness of 1.25 mm is identified as optimal for balancing noise reduction and diagnostic accuracy in head CT scans (Abdulkareem, 2023). In clinical applications such as suspected acute appendicitis, CT scans achieved a diagnostic accuracy of about 96.9%, with sensitivity at 100% and specificity at 96.9%, according to Kibusi et al. (2022).

To reliably assess image quality factors like noise, current evaluation methods use metrics such as standard deviation and noise power spectrum (NPS). Standard deviation is a measure of the variance of pixel values in a uniform region of interest. The standard deviation represents the overall size of the noise. The higher the standard deviation, the more noise there is in the image. On the other hand, the noise power spectrum allows a detailed study by assessing the distribution of noise over multiple spatial frequencies using mathematical operations that allow the characterization of the amount and texture of noise in the image. These techniques allow precise quantification of diagnostic image quality. For the purpose of standardizing these tests, commercially available phantoms are often used. These are physical models that are used to test the noise level, CT number linearity and slice thickness.

Phantoms are specially designed objects that mimic human tissues and are scanned in medical imaging to evaluate, analyze, and optimize the performance of devices like MRI, CT, and ultrasound scanners. These tools provide consistent, reliable results without risking human subjects, enabling technicians to calibrate systems for accuracy and safety. By simulating tissue properties such as density and contrast, phantoms help ensure high-quality images for improved diagnosis and treatment planning, allowing precise adjustments to imaging algorithms and equipment before clinical use.

Phantoms are commercially available and widely used globally, for example, the Philips phantom series, which is typically used for the clinical quality control of computed tomography (CT) systems. These phantoms are constructed with modules for the measurement of critical picture quality metrics such as noise, uniformity and CT number accuracy and are appropriate for regular performance monitoring of Philips CT scanners. Standardized phantoms such as the ACR CT Accreditation Phantom developed by the American College of Radiology are still necessary for accreditation and quality assurance, and the AAPM CT Performance Phantom is commonly used for detailed assessment of noise and spatial resolution. Philips phantoms are often used in clinical practice as they are embedded with manufacturer-specific protocols and workflows. In Asia, companies like Kyoto Kagaku make specialized phantoms like Dynamic Cardiac CT phantoms for simulating motion of the heart and Multi-Energy/Photon-Counting CT phantoms for detailed quantitative studies. CT facilities in the Philippines generally purchase phantoms from international vendors such as Kyoto Kagaku, CIRS and Phantom Laboratory. For example, the Philips Phantom is used as a standard instrument in the Lorma Cancer Institute in San Fernando City to monitor CT scanner performance and to analyze the effect of changes in clinical scanning protocols.

Despite their usefulness, commercially available phantoms have significant limitations. According to Smith et al. (2023), their cost in the Philippines generally ranges from around ₱100,000 to over ₱1,000,000 due to specialized, proprietary materials, complex manufacturing processes, and dependence on specialized manufacturers, which severely limits accessibility. To address these challenges, innovative 3D-printed and gelatin-based phantoms have been developed that better simulate biological tissues and anatomical details (Lee, 2024), improving diagnostic accuracy by up to 15% in localized clinical settings, especially in resource-limited areas like the Philippines.

Gelatin has long been regarded as an excellent material for medical imaging phantoms due to its favorable physical and biological properties. As a natural polymer, gelatin exhibits excellent biocompatibility, making it well-suited to simulate human tissues in laboratory settings. Besides affordability and easy availability, gelatin offers tunable mechanical and optical characteristics that can mimic a variety of tissue stiffness, density, and transparency needed for imaging experiments.

Current research highlights gelatin-based phantoms as cost-effective and customizable alternatives to commercial products. Yusuff (2024) discusses gelatin's adaptability for MRI phantom fabrication, including modification with additives to simulate contrast. Shrimal (2024), comparing gelatin phantoms with commercial counterparts, demonstrated equal or superior imaging resolution and performance, while Badawe (2024) emphasized gelatin's enhanced control over acoustic, mechanical, and structural properties. These advantages, combined with low material costs and ease of preparation, make gelatin phantoms especially valuable in low-resource environments and for iterative prototyping to advance imaging technology.

However, literature review reveals a crucial research gap: no standardized gelatin phantoms reliably mimic human tissues for quality checks like noise testing. While standardized gelatin phantoms exist for ultrasound training, Badawe (2024) notes inconsistencies caused by varying gelatin amounts and mixing techniques, and Dąbrowski et al. (2024) highlight variability in liver phantom preparation. Without uniform recipes tailored for CT metrics, results are difficult to compare. Our study addresses this by creating simple, repeatable gelatin phantoms for CT quality assurance in the Philippines.

Although Hatamikia (2022) focused mainly on 3D-printed thorax phantoms with bone-equivalent radiodensity, the study underscores the urgent need for accurate replication of tissue morphology and imaging properties in phantom fabrication. This highlights the importance of detailed evaluation and optimization of materials such as gelatin phantoms under diverse clinical imaging parameters like kV and mA. Without such thorough characterization, their clinical reliability remains uncertain, emphasizing the need for further research to optimize gelatin phantom compositions and validate their performance under various imaging conditions, thereby enhancing their value as affordable, customizable alternatives.

Specifically, gelatin-based phantoms have proven effective in simulating soft tissue properties. Zhao (2023) demonstrated that changing gelatin concentration (from 12.5% to 25%) can replicate the radiation absorption and mechanical characteristics of human breast tissue in CT. Elisei (2024) highlighted their role in improving clinical training by accurately mimicking patient tissues for safer, more effective CT-guided procedures. Since CT image quality and phantom accuracy heavily depend on X-ray beam energy and tube current/time—which affect attenuation, contrast, noise, and resolution—recent quantitative studies stress controlling these parameters to develop phantoms that closely reflect clinical scanning conditions (Wegner et al., 2023).

To apply these insights practically, researchers fabricating gelatin-based phantoms for CT image noise evaluation will use precise chemical compositions and sample formulations from established studies, such as controlled bovine gelatin concentrations (12% w/v) for tissue mimicry. This phantom was scanned at standard kilovoltage (kV) and tube current (mA) settings for adult abdominal CT scans to quantify noise metrics like standard deviation and noise power spectrum (NPS). Furthermore, researchers aimed to determine differences between the diagnostic performance of locally fabricated gelatin-based phantoms and commercially available phantoms in terms of CT image noise.

Ultimately, this study benefits multiple groups: radiologic students will improve their ability to evaluate CT images and deepen understanding of image quality factors; instructors will gain practical tools to illustrate image quality theories, facilitating better learning; upon securing regulatory approval through Department of Health (DOH) FDA registration as a medical device via a Certificate of Medical Device Registration (CMDR) for Class B-D phantoms, medical physicists and QA teams can use the phantom for standardized testing and calibration, ensuring compliance with safety standards like Administrative Order 2018-0002 and reliable CT imaging performance. Lastly, the study can serve as a reference for future research aimed at creating novel phantoms or advancing CT image quality evaluation.

2. Objectives

This study aimed to locally fabricate a gelatin-based phantom for evaluating the CT image noise.

3. Materials and Methods

This study utilized a quantitative true experimental research design to evaluate the diagnostic performance of a fabricated gelatin-based phantom for computed tomography (CT) image noise assessment. The study focused on determining the effectiveness of the fabricated phantom in comparison with a commercially available Philips phantom using objective CT image quality parameters.

The study was conducted at the Lorma Cancer Institute in San Fernando City, La Union, Philippines. Phantom fabrication was performed in the laboratory facilities of the College of Pharmacy at Lorma Colleges, while CT image acquisition and evaluation were carried out at the CT unit of Lorma Cancer Institute. The materials used in fabricating the phantom included bovine gelatin, sucrose, distilled water, a PLA/acrylic phantom molder, a hotplate, a thermometer, and a refrigeration unit.

The fabricated phantom was prepared by dissolving 12 g of bovine gelatin and 18 g of sucrose in 100 mL of distilled water. The mixture was heated to approximately 75°C with continuous stirring to ensure homogeneity. After complete dissolution, the solution was poured into the phantom molder and refrigerated at 4°C for 48 hours until fully solidified. The phantom remained inside the molder during CT scanning to preserve structural stability and minimize distortion.

CT image acquisition was performed using a standard adult whole-abdomen CT protocol with scanning parameters set at 120 kVp and 300 mAs. One scan was obtained for each phantom under identical conditions. The middlemost axial slice was selected for image evaluation to reduce edge artifacts and ensure consistent analysis. Five regions of interest (ROIs) were systematically positioned at the 0, 3, 6, 9, and 12 o'clock locations within the image. Ten repeated readings were obtained from the same slice to evaluate reproducibility and consistency.

The image quality parameters analyzed in this study included Hounsfield Unit (HU), standard deviation (SD), signal-to-noise ratio (SNR), and noise power spectrum (NPS). Statistical analysis was performed using paired t-test to determine whether a significant difference existed between the fabricated gelatin-based phantom and the commercially available Philips phantom. Statistical significance was set at $p < 0.05$.

To ensure the trustworthiness and reliability of the study, standardized CT imaging protocols and consistent fabrication procedures were strictly followed throughout the experiment. All measurements were obtained using objective quantitative methods, and the data collection process was carefully documented to maintain dependability and confirmability. Ethical approval and institutional permission were secured prior to conducting the study, and all procedures were performed in accordance with laboratory safety and research protocols.

4. Results

The results of the study provided an evaluation of the diagnostic performance of the fabricated gelatin-based phantom for computed tomography (CT) image noise assessment. Analysis of the CT image quality parameters demonstrated the phantom's capability to produce stable and reproducible imaging measurements comparable to a commercially available Philips phantom. The study specifically evaluated Hounsfield Unit (HU), standard deviation (SD), signal-to-noise ratio (SNR), and noise power spectrum (NPS) under a standard adult abdominal CT protocol.

The researchers identified three major findings based on the obtained quantitative measurements: (1) the diagnostic performance of the fabricated gelatin-based phantom, (2) the diagnostic performance of the commercially available Philips phantom, and (3) the significant difference between the fabricated phantom and the commercial phantom in terms of CT image noise assessment. These findings provided insight into the effectiveness, consistency, and applicability of the fabricated phantom for CT image quality evaluation.

Table 1. Diagnostic Performance of Fabricated Phantom

READINGS	MEAN HU	STANDARD DEVIATION	SIGNAL-TO-NOISE RATIO
Reading 1	77.76	9	8.64
Reading 2	77.71	9.43	8.24
Reading 3	77.95	9.96	7.83
Reading 4	76.34	9.72	7.85
Reading 5	76.26	10.30	7.40
Reading 6	78.11	10.24	7.63
Reading 7	76.56	9.8	7.81

Reading 8	77.51	9.48	8.18
Reading 9	77.54	9.94	7.80
Reading 10	76.83	10.79	7.12
TOTAL AVERAGE:	**77.26**	**9.87**	**7.85**

Table 2. Diagnostic Performance of Commercial Phantom

READINGS	MEAN HU	STANDARD DEVIATION	SIGNAL-TO-NOISE RATIO
Reading 1	0	9.81	0
Reading 2	0.37	10.47	0.04
Reading 3	-0.52	10.01	0.05
Reading 4	0.01	10.85	0.00092
Reading 5	-0.69	10.02	0.07
Reading 6	-0.68	9.93	0.07
Reading 7	-0.58	10.47	0.06
Reading 8	0.31	11.18	0.03
Reading 9	-0.23	11.02	0.02
Reading 10	-0.62	10.69	0.06
TOTAL AVERAGE:	**-0.26**	**10.44**	**0.03**

Table 3. Significant Difference in CT Image Noise Between Fabricated Phantom and Philips Phantom

	FABPHANTOM	**PHILIPS PHANTOM**
Mean	9.866	10.445
Variance	0.256782	0.237161
Observations	10	10
Pearson Correlation	0.020486	
Hypothesized Mean Difference	0	
Df	9	
t Stat	-2.63227	
P(T<=t) one-tail	0.013628	
t Critical one-tail	1.833113	
P(T<=t) two-tail	0.027257	
t Critical two-tail	2.262157	

5. Discussions

The study evaluated the diagnostic performance of the fabricated gelatin-based phantom for computed tomography (CT) image noise assessment in comparison with a commercially available Philips phantom. The discussion was organized according to the three major result categories derived from the study: (1) diagnostic performance of the fabricated gelatin-based phantom, (2) diagnostic performance of the the commercially available Philips phantom, and (3) comparison between the fabricated and commercial phantom in terms of CT image noise assessment.

The first major finding focused on the diagnostic performance of the fabricated gelatin-based phantom. The results demonstrated that the fabricated phantom produced stable Hounsfield Unit (HU), standard deviation (SD), signal-to-noise ratio (SNR), and noise power spectrum (NPS) measurements under standardized CT imaging conditions. The obtained HU values indicated that the gelatin-sucrose composition possessed tissue-equivalent attenuation characteristics suitable for CT image evaluation. Furthermore, the repeated measurements showed reproducibility and consistency, suggesting that the fabricated phantom maintained structural and radiologic stability throughout the scanning process. The stability of the SD and SNR values also reflected controlled image noise behavior during image acquisition.

The second major finding described the diagnostic performance of the commercially available Philips phantom. The commercial phantom demonstrated stable and standardized image quality measurements, particularly in terms of HU and SD values. Its near water-equivalent attenuation properties confirmed its effectiveness as a reference phantom for CT quality assurance and image calibration. The reproducibility of its measurements further established the reliability of commercially manufactured phantoms for maintaining consistent CT image quality evaluation. These findings support the continued use of commercial phantoms as standard references in radiologic imaging and quality assurance procedures.

The third major finding explored the comparison between the fabricated gelatin-based phantom and the commercially available Philips phantom. Statistical analysis using paired t-test revealed a significant difference between the two phantoms in terms of CT image noise assessment. The difference may be attributed to variations in material composition, density, and structural uniformity between the fabricated gelatin-based phantom and the highly standardized commercial phantom. Commercial phantoms are specifically engineered using optimized water-equivalent materials, whereas the fabricated phantom utilized gelatin and sucrose as alternative tissue-mimicking substances.

Despite the statistical difference, the fabricated phantom demonstrated practical potential for CT image quality evaluation because of its ability to produce measurable and reproducible imaging parameters. The findings suggest that locally fabricated gelatin-based phantoms may serve as economical alternatives for educational applications, research activities, and preliminary quality assurance procedures, particularly in institutions with limited access to commercial phantoms.

The findings of this study are consistent with previous literature emphasizing the feasibility of gelatin-based phantoms for medical imaging applications. Previous studies reported that gelatin concentration and material composition significantly influence attenuation properties and image quality behavior during CT imaging. Similarly, the addition of sucrose in the fabricated phantom contributed to modifying density and attenuation characteristics, allowing the phantom to simulate soft tissue properties more effectively.

Another important observation in the study was the practicality and accessibility of the fabricated phantom. Compared with commercially available phantoms, the fabricated gelatin-based phantom was easier to produce using inexpensive materials and simple fabrication procedures. In addition, the phantom was capable of undergoing repeated CT scans for approximately one to two months; however, prolonged storage may lead to mold formation and material degradation, which can affect long-term consistency and image quality performance.

This study was limited by the use of only one CT imaging protocol and a single CT scanner configuration. Future studies may further evaluate the fabricated phantom using different CT exposure parameters, reconstruction algorithms, scanner manufacturers, and additional image quality metrics such as spatial resolution, contrast resolution, and radiation dose assessment to further validate its broader clinical applicability.

6. Conclusions

The fabricated gelatin-based phantom demonstrated stable and reproducible performance in computed tomography (CT) image noise assessment using standard adult abdominal CT imaging parameters. The study successfully evaluated the phantom's diagnostic performance through measurements of Hounsfield Unit (HU), standard deviation (SD), signal-to-noise ratio (SNR), and noise power spectrum (NPS), confirming its capability to produce quantifiable and consistent image quality results.

The fabricated phantom exhibited tissue-equivalent attenuation characteristics suitable for CT image evaluation. Repeated measurements obtained from the selected middlemost slice revealed consistent image noise behavior and reliable signal reproducibility throughout the scanning process. These findings indicate that the combination of bovine gelatin, sucrose, and distilled water was effective in producing a low-cost phantom suitable for CT image quality assessment.

The commercially available Philips phantom demonstrated stable water-equivalent attenuation properties and maintained standardized image quality measurements throughout the study. As a commercially manufactured phantom specifically designed for CT quality assurance, it remained highly effective as a reference standard for evaluating CT image noise performance.

Statistical analysis revealed a significant difference between the fabricated gelatin-based phantom and the commercially available Philips phantom in terms of CT image noise assessment. Despite this difference, the fabricated phantom demonstrated practical value as an economical and accessible alternative for educational purposes, research applications, and preliminary quality assurance procedures, particularly in institutions with limited access to commercial phantoms.

The study further established that the fabricated phantom can undergo repeated CT scanning for approximately one to two months while maintaining acceptable imaging performance. However, prolonged storage may result in mold formation and material degradation, which may affect long-term consistency and structural stability.

Based on the findings of the study, the researchers recommend further optimization of the gelatin-based phantom formulation to improve homogeneity, durability, and tissue-equivalent properties. Future studies should evaluate the phantom using different CT scanner systems, reconstruction algorithms, and imaging protocols to determine broader applicability. Additional image quality parameters such as spatial resolution, contrast resolution, and radiation dose assessment may also be investigated to further validate the effectiveness of the fabricated phantom for CT quality assurance and imaging research applications.

7. Acknowledgements

This research became a reality through the generous support, encouragement, and assistance of many individuals. The researchers would like to express their heartfelt gratitude and sincere appreciation to the following:

Foremost, the researchers offer this achievement to the Almighty God for granting them wisdom, strength, patience, and guidance throughout the completion of this study. Through His grace, determination amidst the challenges encountered during the conduct of this research became possible.

The researchers would also like to extend their deepest gratitude to their research adviser, Mr. Mark Anthony C. Burgonio, MSc, for his invaluable guidance, constructive suggestions, patience, and encouragement throughout the conduct of the study. His expertise and thoughtful advice greatly contributed to the development of the gelatin-based phantom and the successful completion of the CT image noise evaluation.

Special acknowledgment is likewise given to Mrs. Marites C. Pagdilao, MAN, their research instructor, for her continuous support, insights, and academic guidance that helped strengthens the quality and direction of this research.

The researchers are sincerely grateful to their families for their unwavering love, understanding, encouragement, and moral support, especially during times when difficulties seemed overwhelming.

The researchers also extend their appreciation to the distinguished members of the panel headed by the Dean, Ms. Gryn T. Salagma, RRT, MPH**,** together with Mrs. Joylyn P. Baniaga, LPT, MAME and Ms. Ivy Rose C. Orozco, RPh, CIP**,** for sharing their expertise, constructive recommendations, and valuable time in evaluating and improving this study.

Finally, to all friends and classmates**,** thank you for the encouragement, kindness, and support extended throughout the completion of this research. This study would not have been possible without your help and motivation.

8. References

Abdulla, S. (2021c, October 10). *CT image quality - Radiology Cafe. Radiology Cafe*

Drive Result: https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-image-quality/

Abdulkareem, N. K., Hajee, S. I., Hassan, F. F., Ibrahim, I. K., Al-Khalidi, R. E. H., & Abdulqader, N. A. (2023). *Investigating the slice thickness effect on noise and diagnostic content of single-source multi-slice computerized axial tomography. Journal of medicine and life, 16(6), 862–867.*

Drive Result: https://doi.org/10.25122/jml-2022-0188

Ahmad, M. S., Suardi, N., Shukri, A., Mohammad, H., Oglat, A. A., Alarab, A., & Makhamrah,

O. (2020). *Chemical Characteristics, Motivation and Strategies in choice of Materials used as Liver Phantom: A Literature Review. Journal of medical ultrasound, 28(1), 7–16.*

Drive Result: https://doi.org/10.4103/JMU.JMU_4_19

Alghuwainem, N. a. O. (n.d.). *The Role of CT scan and MRI in Evaluating Bone Marrow Diseases in Children. Journal of Namibian Studies History Politics Culture, 42, 187–205.*

Drive Result: https://doi.org/10.59670/6z2vdc40

Badawe, H. M., Raad, P., & Khraiche, M. L. (2024). *High-resolution acoustic mapping of tunable gelatin-based phantoms for ultrasound tissue characterization. Frontiers in Bioengineering and Biotechnology, 12, 1276143.*

Drive Result: https://doi.org/10.3389/fbioe.2024.1276143

Cammin, J., Fung, G. S. K., Fishman, E. K., Siewerdsen, J. H., Stayman, J. W., & Taguchi, K. (2014). *A biological phantom for evaluation of CT image reconstruction algorithms. In Medical Imaging 2014: Physics of Medical Imaging (Vol. 9033). SPIE.*

Drive results*:* https://doi.org/10.1117/12.2043714

Computed Tomography (CT). (n.d.). *National Institute of Biomedical Imaging and Bioengineering.*

Drive Result: https://www.nibib.nih.gov/science-education/science-topics/computed tomography-ct

Elisei, R. C., Graur, F., Szold, A., Melzer, A., Moldovan, S. C., Motrescu, M., Moiş, E., Popa, C.,

Pîsla, D., Vaida, C., Tudor, T., Coţe, A., & Al-Hajjar, N. (2024). *Gelatin-Based Liver Phantoms for Training Purposes: A Cookbook approach. Journal of Clinical Medicine, 13(12), 3440.*

Drive Result: https://doi.org/10.3390/jcm13123440

Fohely, F., Oglat, A. A., Sabarna, K., Shweiki, Z., Hamoudeh, B., Shalaan, R., Fohely, F., Oglat, A., Sabarna, K., Shweiki, Z., Hamoudeh, B., & Shalaan, R. (2022b). *Fabrication of low-cost realistic three-dimensional static kidney phantom for ultrasound-guided biopsy applications. Journal of Medical Ultrasound, 30(1), 36–40.*

Drive results: https://doi.org/10.4103/jmu.jmu_181_20

Hatamikia, S., Jaksa, L., Kronreif, G., Birkfellner, W., Kettenbach, J., Buschmann, M., & Lorenz, A. (2022). *Silicone phantoms fabricated with multi-material extrusion 3D printing technology mimicking imaging properties of soft tissues in CT. arXiv*.

Drive Result: https://arxiv.org/abs/2212.03116

Hoeijmakers, E. J. I., Martens, B., Wildberger, J. E., Flohr, T. G., & Jeukens, C. R. L. P. N. (2025). *Objective assessment of diagnostic image quality in CT scans: what radiologists and researchers need to know. Insights into imaging, 16(1), 154.*

Drive Result: https://doi.org/10.1186/s13244-025-02037-y

Hsieh, J., & Flohr, T. (2021). *Computed tomography recent history and future perspectives. Journal of medical imaging (Bellingham, Wash.), 8(5), 052109*.

Drive results: doi.org/10.1117/1.JMI.8.5.052109

Imaging Solutions. (2020, June). *QA phantoms.*

Drive Results: https://imagingsol.com.au/wp-content/uploads/2020/06/QA-Phantoms-003.pdf

Imaging Solutions. (2020, June). *Training phantoms.*

Drive results: https://imagingsol.com.au/wp-content/uploads/2020/06/Training-Phantoms- 003.pdf

Kibusi, S. A., Ntwenya, J., Mteta, A., & Kabangila, R. (2021). *Diagnostic accuracy of computed tomography in adults with suspected acute appendicitis at the emergency department in a private tertiary hospital in Tanzania. Radiology Research and Practice, 2021, Article 6640267.*

Drive Result: https://doi.org/10.1155/2021/6640267

Kreager, B., Wei-Yi, C., & Wu, H. (2026). Biopsy Needle Integrated with Rotational Oblique Spectral Ultrasound (ROSUS) Imaging. Sensors, 26(4), 1098.

Merrell, K. (n.d.-b). *Patient specific tissue emulating phantoms for image-guided intervention applications. RIT Digital Institutional Repository.* https://repository.rit.edu/theses/11951/?fbclid=IwY2xjawOZFaRleHRuA2FlbQIxMABicmlkETFiTGhENW1RRVFqV0tBVnFUc3J0YwZhcHBfaWQQMjIyMDM5MTc4ODIwMDg5MgABHsQtJAJ-BgMd BC4TwgpAXLfwEfPE79m4VPvJFo7kAmX7k0dlmfVPbVfsC35_aem_v0Q_p8FeZziY98VLtvZkQg

Salvador-Ribés, C., Soler-Pons, C., Sánchez-García, M. J., Fechter, T., Olivas, C., Torres-Espallardo, I., Pérez-Calatayud, J., Baltas, D., Mix, M., Martí-Bonmatí, L., & Carles, M. (2025). *Open-source phantom with dedicated in-house software for image quality assurance in hybrid PET systems. EJNMMI physics, 12(1), 35.*

Drive Result: https://doi.org/10.1186/s40658-025-00741-8

Shrimal, P., Thakur, N., Gopinath, B., Mishra, P. R., Rajalekshmi, R., Bhoi, S., Aggarwal, P., Jamshed, N., & Upadhyay, A. D. (2024). *Comparing commercial versus low-cost* *gelatinous phantoms for ultrasound-guided needle tracking: A randomized crossover trial among emergency medicine residents. Turkish Journal of Emergency Medicine, 24(2), 103–110.*

Drive Result: https://doi.org/10.4103/tjem.tjem_206_23

Statista. (2025, June 26). *Computer tomography (CT) - number of examinations in selected countries 2022.*

Drive Result: https://www.statista.com/statistics/283085/computer-tomography examinations-in-selected-countries/

Yusuff, H., Chatelin, S., & Dillenseger, J.-P. (2024). *Narrative review of tissue-mimicking materials for MRI phantoms: Composition, fabrication, and relaxation properties. Radiography, 30(6), 1655–1668.*

Drive Result: https://doi.org/10.1016/j.radi.2024.09.063

Zhao, M., Zhou, M., Cao, X., Feng, J., Pogue, B. W., Paulsen, K. D., & Jiang, S. (2023). *Stable tissue-mimicking phantoms for longitudinal multimodality imaging studies that incorporate optical, CT, and MRI contrast. Journal of biomedical optics, 28(4), 046006.*

Drive Result: https://doi.org/10.1117/1.JBO.28.4.046006

Tan, L., Li, K., Huang, H., Jia, F., & Ning, G. (2023). Phantom and clinical studies on low-dose CT protocol using water-equivalent diameter. Radiation Protection Dosimetry, 199(7), 670–679. https://doi.org/10.1093/rpd/ncad130

Hernandez, A. M., Burkett, G. W., Pham, N., & Abbey, C. K. (2023).

Performance of high-resolution CT for detection and discrimination tasks: A phantom study. Medical Physics, 50(4), 2037–2048. https://doi.org/10.1002/mp.16194

Gallo, P., D'Alessio, A., Pascuzzo, R., et al. (2024).

Enhancing soft tissue differentiation with different dual-energy CT systems: A phantom study. Applied Sciences, 14(5), 1724. https://doi.org/10.3390/app14051724

Zhang, X., Bao, S., Wang, M., Xu, Z., Yan, F., & Yang, W. (2024). Stability and accuracy of fat quantification on photon-counting detector CT with various scan settings: A phantom study. European Journal of Radiology, 177, 111545.

Tafti, S., Abadia, A., Fung, G., Ramirez-Giraldo, J. C., & O'Doherty, J. (2024). Comparison of Hounsfield Unit variability between two same model photon counting CT detector systems: A phantom study applied to lung CT. Physica Medica, 126, 104828. https://doi.org/10.1016/j.ejmp.2024.104828

Watanabe, R., Zensho, A., Ohishi, Y., & Funama, Y. (2023). Image-quality characteristics in the longitudinal direction from different image-reconstruction algorithms during head CT: A phantom study. Radiology Research and Practice.

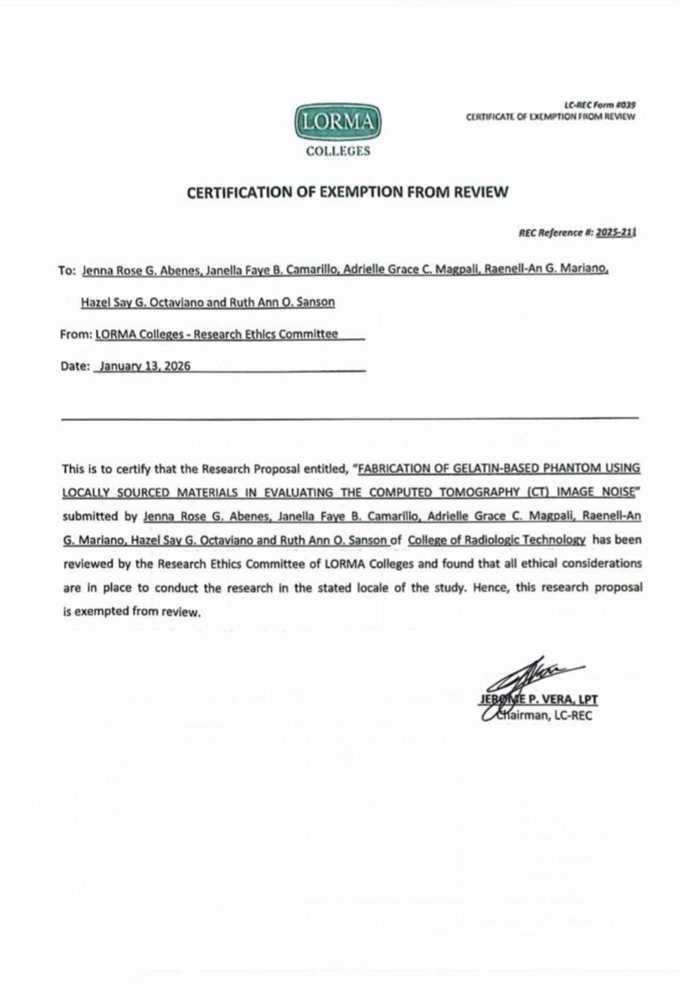
Kim, J., et al. (2025). Image quality and radiation dose of reduced-dose abdominopelvic CT with deep learning reconstruction. Scientific Reports. https://www.nature.com/articles/s41598-025-11184-7

Zhang, M., et al. (2024). Low-dose lung CT: Optimizing diagnostic radiation dose – A phantom study. Journal of Medical Imaging. https://pmc.ncbi.nlm.nih.gov/articles/PMC11626076/

Funama, Y., Nakaura, T., Hasegawa, A., Sakabe, D., Oda, S., Kidoh, M., Nagayama, Y., & Hirai, T. (2023). Noise power spectrum properties of deep learning-based reconstruction and iterative reconstruction algorithms: Phantom and clinical study. European journal of radiology, 165, 110914. https://doi.org/10.1016/j.ejrad.2023.110914

9. Appendices

APPENDIX A
Certification of Exemption from Review



LORMA
COLLEGES

LC-REC Form #039
CERTIFICATE OF EXEMPTION FROM REVIEW

CERTIFICATION OF EXEMPTION FROM REVIEW

REC Reference #: 2025-211

To: Jenna Rose G. Abenes, Janella Faye B. Camarillo, Adrielle Grace C. Magpali, Raenell-An G. Mariano, Hazel Say G. Octaviano and Ruth Ann O. Sanson

From: LORMA Colleges - Research Ethics Committee

Date: January 13, 2026

This is to certify that the Research Proposal entitled, "FABRICATION OF GELATIN-BASED PHANTOM USING LOCALLY SOURCED MATERIALS IN EVALUATING THE COMPUTED TOMOGRAPHY (CT) IMAGE NOISE" submitted by Jenna Rose G. Abenes, Janella Faye B. Camarillo, Adrielle Grace C. Magpali, Raenell-An G. Mariano, Hazel Say G. Octaviano and Ruth Ann O. Sanson of College of Radiologic Technology has been reviewed by the Research Ethics Committee of LORMA Colleges and found that all ethical considerations are in place to conduct the research in the stated locale of the study. Hence, this research proposal is exempted from review.

JEROME P. VERA, LPT
Chairman, LC-REC

10. Author(s) Biodata

Ms. Jenna Rose G. Abenes, Ms. Janella Faye B. Camarillo, Ms. Adrielle Grace C. Magpali, Ms. Raenell-An G. Mariano, Ms. Hazel Say G. Octaviano, and Ms. Ruth Ann O. Sanson are Bachelor of Science in Radiologic Technology students from Lorma Colleges. Together with their research adviser, Mr. Mark Anthony C. Burgonio, they conducted a study entitled *"Fabrication of a Gelatin-Based Phantom for Computed Tomography Image Noise Assessment."* United by their passion for medical imaging and radiologic research, the researchers explored the development of a low-cost gelatin-based phantom for CT image quality evaluation. Their study reflects their dedication to advancing knowledge in computed tomography quality assurance, phantom fabrication, and diagnostic imaging research.