ORIGINAL ARTICLE

Effects of Different Hijab Fabrics on Image Quality in Skull X-Ray using Computed Radiography

Nuramisha Diana Tamson[1], Iqbal Jamaludin[1,2,3,*]

[1]Department of Diagnostic Imaging and Radiotherapy, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia
[2]Integrated Omics Research Group (IORG), Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia
[3]Children Health and Wellbeing Research Group, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia

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ABSTRACT

Background: Covering the aurah in Islam is considered a sign of respect, dignity, and privacy. In skull x-ray examination, female patients often feel uncomfortable when being requested to remove their hijab for skull x-ray examination. Therefore, this study aims to evaluate the effects on radiographic image quality in PA (0°) skull x-ray examination when using different types of hijab materials. **Methods:** This study is conducted by using the skull part of Kyoto Kagaku phantom, with the help of immobilisation aids. The phantom is exposed without hijab at optimum exposure factor that is used as a reference image and been compared with the image quality produced by the x-ray examination using three different hijab materials. Each hijab materials (Premium Chiffon Georgette, Premium Valencia Satin and Premium Cotton Rayon) then been exposed together with phantom using three different exposure factors: low (61.5 kVp, 20 mAs), optimum (73 kVp, 10 mAs) and high (83 kVp, 5 mAs). Four experienced observers blindly graded the image quality using Visual Grading Analysis (VGA). The results were analysed by using Kruskal-Wallis to find the effect of different hijab materials on optimum exposure, while Friedman test was used to find any significant findings between different hijab materials and three different exposure factors: low, optimum and high. **Results:** From the Kruskal-Wallis test, the radiographic image quality of all three hijab materials produce no significant difference when compared with skull x-ray image without hijab. Friedman test found only hijab material of Premium Valencia Satin when exposed with 61.5 kVp 20 mAs (low), 73 kVp 10 mAs (optimum) and 83 kVp 5 mAs (high) to be significant (p-value=0.022). **Conclusion:** It can be concluded that Premium Chiffon Georgette and Premium Cotton Rayon are suitable to be used in skull x-ray examination as they did not produce any notable artifacts on skull x-ray radiograph, while special consideration must be made for patient wearing hijab material of Premium Valencia Satin that will undergo skull x-ray examination.

INTRODUCTION

In medical imaging practice, different types of examinations require different patient preparation. Generally, some x-ray procedures involve the removal of clothing and materials from the region of interest (ROI) to avoid any presence of artifacts. Since the purpose of doing skull examination is to help doctors to detect any injuries of the bone surrounding the brain, therefore it is necessary to remove hijab before undergoing the examination. The presence of hijab material during skull X-ray examinations needs special consideration, as it has the potential to introduce artifacts into the radiographic image, consequently degrading image quality. However, for female Muslim patients, the prospect of removing the hijab during the examination may lead to discomfort, as it is considered part of the aurah, which should not be exposed to non- mahram individuals. The hijab may be removed in the presence of healthcare workers when the patient is seeking treatment for relevant medical conditions. However, privacy concerns might cause discomfort for patients and potentially hinder the care they receive (Rehman et al., 2022). Due to that, not emphasizing aurah in radiography may results in dissatisfaction among female Muslim patients. However, the act of removing the hijab to avoid artifacts for skull x-ray can be considered as violating their privacy when it is not well-informed. The presence of artifacts in radiographs may impair image quality, obscure abnormalities and also can mimic clinical features (Drost et al., 2008). An X-ray

* *Corresponding author.*
E-mail address: iqbaljamaludin@iium.edu.my

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artifact is an imperfection in image quality that can obscure the intended subject, potentially leading to a misdiagnosis if it is mistaken for a foreign body (Sheen, 2024). This can lead to misinterpretation due to the hindered visualisation of the object of interest.

Nevertheless, only few studies have been conducted to investigate the real effect of hijab materials on plain radiographs and to show medical imaging acceptability. In the study by Amran (2016) of jubah dress materials and image quality on knee examination, it has been reported that the radiographs are still deemed acceptable by radiologists even though there is presence of artifacts on the image. Additionally, Johari (2014) has noted in his study that the presence of sport trousers leads to artifacts on image although the images remain deemed acceptable. Therefore, this study aims to tackle the issue of preserving aurah for female Muslim in skull examination as discussed above by evaluating the three different hijab materials (Premium Chiffon Georgette, Premium Valencia Satin and Premium Cotton Rayon) and its effect on radiographic image quality.

MATERIALS AND METHODS

This study was conducted at the Diagnostic Imaging Laboratory, Department of Diagnostic Imaging and Radiotherapy (DDIR), Kulliyyah of Allied Health Sciences (KAHS), International Islamic University Malaysia (IIUM), Bandar Indera Mahkota, Kuantan, Pahang by using a Computed Radiography (CR) system.

Materials Used

The study was conducted by using a PBU-31 head phantom that is available at the laboratory. The head phantom mimics the features and characteristics of human tissue, especially the head part, offering an accurate simulation for experimental purposes. Images were evaluated by four assessors: two academicians and two radiographers of DDIR, KAHS, IIUM Kuantan by using Visual Grading Analysis (VGA) score and analysed using SPSS test.

This study used three different types of hijabs that are commonly used by people nowadays which were Premium Chiffon Georgette, Premium Valencia Satin and Premium Cotton Rayon. The reason these materials were chosen is that they are widely popular among women for contemporary fashion and daily wear.

Image Acquisition

Head phantom was positioned in posteroanterior (PA) position with the use of immobilisation devices to securely hold it in place. The CR tube was positioned perpendicular to the IR and directed to the head phantom by using a horizontal beam, as shown in Figure 1. The procedure started with control study (without hijab) with 73 kVp and 10 mAs which represents the optimum exposure settings commonly employed in hospital practice. Each of the three types of hijab materials; Chiffon (Figure 2), Cotton (Figure 3) and Satin (Figure 4), were then applied to the phantom. Each material then was exposed with three different kilovoltage peak (kVp) and milliampere-seconds (mAs).

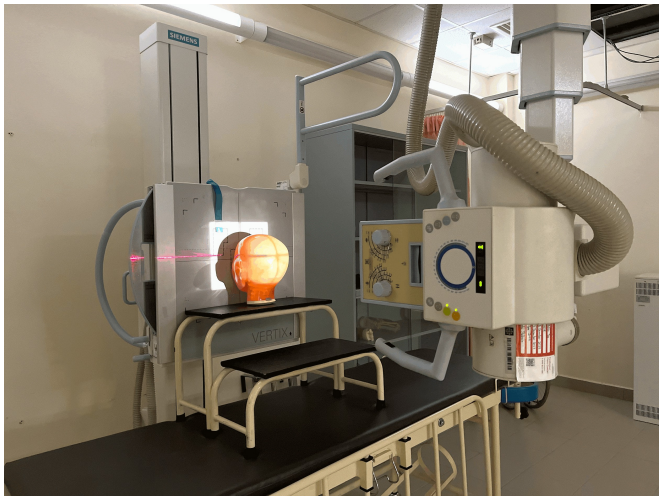

Figure 1: Position of the Head Phantom Without Hijab in PA (0^0) Skull Examination

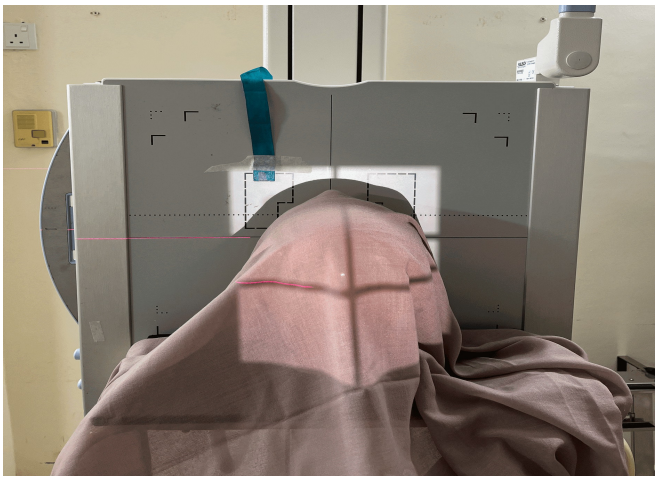

Figure 2: Head Phantom with Premium Chiffon Georgette Hijab in PA (0^0) Skull Examination

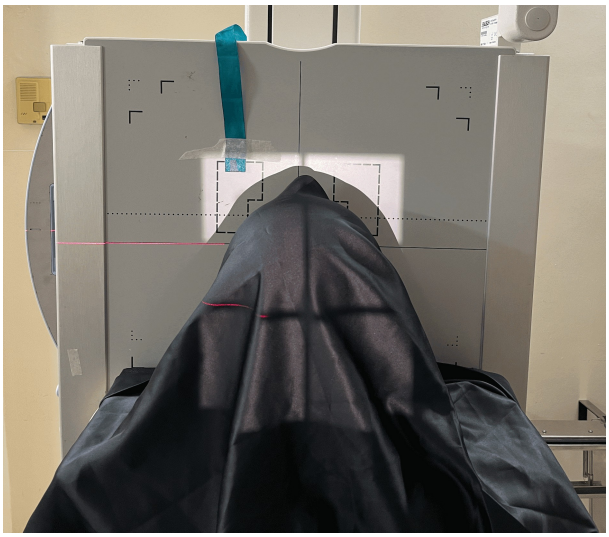

Figure 3: Head Phantom with Premium Cotton Rayon Hijab in PA (0^0) Skull Examination

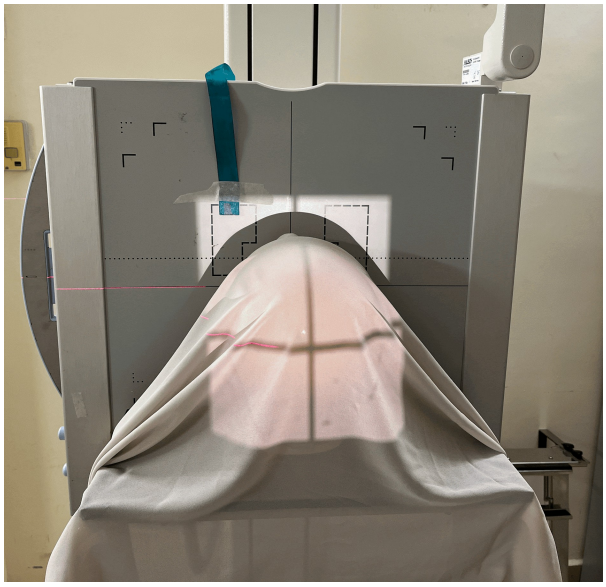

Figure 4: Head Phantom with Premium Valencia Satin Hijab in PA (0^0) Skull Examination

Imaging Parameters

15% kVp rule was used to optimise the image quality of x-ray. According to the rule, changing the kVp by 15% can affect image contrast in a way that is comparable to doubling or halving the mAs while keeping the exposure same. This technique is needed to evaluate which exposure factor is compatible with the materials. According to McQuillen (2011), the 15% kVp rule is used to adjust the kVp to correct for over or under penetration in imaging. The rule states that reducing kVp by 15% can improve image quality. Conversely, increasing kVp by 15% can increase film density, similar to doubling the mAs. Following this principle allows modifications to improve contrast and ensure accurate visualisation of anatomical structures, particularly when contrast is insufficient despite adequate density levels. Additionally, adhering to this rule may reduce radiation exposure, as increasing kVp often decreases required mAs, thereby minimizing patient radiation absorption (Yaakob et al., 2007).

Image Processing

All images were processed by the image reader and displayed on the monitor, after all the exposures were completed. No image manipulation was performed at the monitor. Each image was labelled and saved on the monitor according to the material and exposure level (low kVp, optimal, and high kVp) using a coding system. The initial image was the control image, followed by chiffon, cotton, and satin images. The images were saved in separate folders in the computer system.

Radiographic image quality was evaluated by using VGA. In the VGA study, the radiographic images were graded by four assessors, two academicians and two radiographers from DDIR, KAHS. The gradings took into account how well-defined anatomical structures appear in the image. The image criteria were taken from European Guidelines for diagnostic images from European Commission (European Commission, 1996). For VGA study, image quality criteria were scored on a scoring scale, involving observers for assessing images on a display platform within a suitable environment, followed by statistical analysis (Precht et al., 2019). In this study, the VGA score for reference image was assumed to have a neutral value which is equal to zero for all visualised structures. The reference image was used as a control study which the observer will visually compare the target structure in the test images with the reference image to determine whether they meet specified criteria (Ludewig et al., 2010). There was a total of 10 images including reference images. The score given by the observers were calculated using the equation from the study of Kheddache et al. (2004).

RESULTS

Comparison Of the Radiographic Image Quality Between Three Different Types Of Hijab Materials For Optimum Exposure Factor

Table 1 shows the VGA score obtained from each criterion at optimum exposure; 73 kVp and 10 mAs by all hijab materials. The VGA scores for all materials were slightly lower than the reference image, indicating that the visualisation of the temporal bone was poorer when wearing a hijab. Moreover, both Premium Chiffon Georgette and Premium Valencia Satin have the same

VGA score of -0.0833 for the visualisation of the floor of the sella which indicates a decrease in image quality as the VGA score was slightly inferior to the reference image. Meanwhile for Premium Chiffon Georgette showed a decrease in visualisation of outer and inner lamina of cranial vault while the other two hijab materials maintained the same image quality as reference image, with VGA scores of 0.

Table 1: The VGA criteria and score obtained at optimum exposure for Premium Chiffon Georgette, Premium Cotton Rayon and Premium Valencia Satin compared to reference image

No	Criteria	VGA Scores		
		Premium Chiffon Georgette	Premium Cotton Rayon	Premium Valencia Satin
1	Visually sharp reproduction of the outer and inner lamina of the cranial vault	-0.0833	0	0
2	Visually sharp reproduction of the floor of the sella	-0.0833	0	-0.0833
3	Visually sharp reproduction of the apex of the petrous temporal bone	-0.1667	-0.25	-0.1667

Optimum exposure factor of 73 kVp, 10 mAs

VGA Score for Premium Chiffon Georgette At Different Tube Potentials For PA (0^0) Skull X-Ray Examination

Table 2 shows that low exposure factor results in better image quality for Premium Chiffon Georgette across all criteria. This indicates that the image is slightly better than the reference image compared to other exposure factors. Meanwhile 73 kVp with 10 mAs and 83 kVp with 5 mAs have lower VGA scores which indicate poor visualisations for all listed criteria when exposed with Premium Chiffon Georgette hijab. It results in overexposed images with reduced contrast and detail across the listed criteria.

VGA Score for Premium Cotton Rayon at Different Tube Potentials Energy For PA (0^0) Skull X-Ray Examination

Table 3 shows that 61.5 kVp with 20 mAs have an increase in VGA score when compared to reference image. The VGA score for visualisation of floor of the sella was more than 0 indicating superior radiographic image quality compared to images taken at 73 kVp and 83 kVp. At 73 kVp and 20 mAs, the image was slightly inferior for visualizing the apex of the petrous temporal bone, with a VGA score of - 0.25, while the visualisation of other structures remains similar to the reference image, with VGA scores of 0. Meanwhile, high exposure factor (83 kVp and 5 mAs) gives negative results with VGA score less than 0 for visualisation of all listed structures.

Table 2: The VGA criteria and score obtained by Premium Chiffon Georgette with varying exposure factors compared to the reference image of PA Skull (0^0) projection

No	Criteria	VGA for Premium Chiffon Georgette		
		61.5 kVp, 20 mAs	73 kVp, 10 mAs	83 kVp, 5 mAs
1	Visually sharp reproduction of the outer and inner lamina of the cranial vault	+0.0833	-0.0833	-0.25
2	Visually sharp reproduction of the floor of the sella	+0.1667	-0.0833	-0.25
3	Visually sharp reproduction of the apex of the petrous temporal bone	+0.0833	-0.1667	-0.3333

Table 3: The VGA criteria and score obtained by Premium Cotton Rayon with varying exposure factors compared to the reference image of PA Skull (0^0) projection

No	Criteria	VGA for Premium Cotton Rayon		
		61.5 kVp, 20 mAs	73 kVp, 10 mAs	83 kVp, 5 mAs
1	Visually sharp reproduction of the outer and inner lamina of the cranial vault	0	0	-0.0833
2	Visually sharp reproduction of the floor of the sella	+0.0833	0	-0.3333
3	Visually sharp reproduction of the apex of the petrous temporal bone	0	-0.25	-0.4167

VGA Score for Premium Valencia Satin At Different Tube Potentials For PA (0^0) Skull X-Ray Examination

Table 4 shows average score for low exposure factor was increased for visualising floor of the sella compared to reference image. However, it showed poor visualisation of apex of the petrous temporal bone as the VGA score was less than 0. In the meantime, 83 kVp 5 mAs represents worsened radiographic image quality with VGA scores below 0 for all criteria. This indicates that with high exposure factors, Premium Valencia Satin results in low visualisation of the structures. At 73 kVp, the score was not significantly worse compared to 83 kVp, but it still contributes to the overall descending pattern.

Table 4: The VGA criteria and score obtained by Premium Valencia Satin with varying exposure factors compared to the reference image of PA Skull (0^0) projection

No	Criteria	VGA for Premium Cotton Rayon		
		61.5 kVp, 20 mAs	73 kVp, 10 mAs	83 kVp, 5 mAs
1	Visually sharp reproduction of the outer and inner lamina of the cranial vault	0	0	-0.25
2	Visually sharp reproduction of the floor of the sella	+0.1667	-0.0833	-0.5
3	Visually sharp reproduction of the apex of the petrous temporal bone	-0.0833	-0.1667	-0.5833

The result of the Friedman test found that the p-value is 0.038 which indicates there was significant difference in Premium Valencia Satin when exposed with 61.5 kVp 20 mAs, 73 kVp 10 mAs, and 83 kVp 5 mAs. Therefore, Dunn-Bonferroni post hoc analysis was conducted as shown in Table 5 to determine which pairs of conditions differed significantly. According to the result, there was a statistically significant difference between the pair of Premium Valencia Satin in low exposure and Premium Valencia Satin in high exposure, as indicated by a p-value of 0.022. This suggested that the choice of exposure settings significantly affects the image quality when comparing satin under low and high exposure conditions. Therefore, it can be stated that Premium Valencia Satin at high exposure factor resulted in poor image quality compared to low exposure factor. Conversely, there was no significant difference observed between the pair of Premium Valencia Satin in optimum exposure and low exposure, as well as between Premium Valencia Satin in high exposure and medium exposure as the p-values are 0.052 and 0.724, respectively.

Table 5: Pairwise Comparison for Premium Valencia Satin in Dunn-Bonferroni Post-Hoc Test Analysis

Sample 1 – Sample 2	Test statistic	Std. Error	Std. Test Statistic	p-value	Adj. Sig.
Satin_high-Satin_opt	1.375	0.707	1.945	0.052	0.155
Satin_high-Satin_low	1.625	0.707	2.298	0.022	0.065
Satin_opt-Satin_low	0.250	0.707	0.354	0.724	1.000

CONCLUSION

Comparison Of the Radiographic Image Quality Between Three Different Types Of Hijab Materials (Premium Chiffon Georgette, Premium Cotton Rayon and Premium Valencia Satin) For Optimum Exposure Factor

This study was conducted to evaluate the effects of different hijab materials when exposed to the optimum exposure factor which is 73 kVp and 10 mAs. Throughout this study, the Premium Chiffon Georgette hijab has the lowest VGA score among three different materials. It can be concluded that the presence of Premium Chiffon Georgette hijab gives low image quality to the skull examination. This can be seen from the VGA score of Premium Chiffon Georgette, which is less than 0, while the scores for the other two materials are higher. However, it could be due to the lower kVp used that was insufficient to penetrate the material.

According to Yaakob et al. (2007), decreasing the kVp by 15% leads to a reduction of x-rays energy and penetration power. It means that, there was a decrease in the intensity of X-rays that penetrate patients resulting in lower energy levels of the X-rays and reducing the penetration power of the X-ray beam. As a result, 73 kVp and 10 mAs was insufficient to penetrate Premium Chiffon Georgette which results in underexposed image.

Meanwhile, Premium Cotton Rayon has a better VGA score and most of the score seems to be equal to the reference image compared to Premium Chiffon Georgette and Premium Valencia Satin. It can be seen that most of the scores for Premium Cotton Rayon are equal to 0 indicating there were no difference in image quality with

the reference image. Even though the visualisation of the apex of the petrous temporal bone was not clearly be visualised from observers' point of view, the score was still near to the reference image. Thus, it can be said that the radiograph can be still acceptable and Premium Cotton Rayon gives adequate image quality to the skull radiograph. The exposure and penetration are adequate even when Premium Cotton Rayon was placed on the head phantom. It indicates that the combination of 73 kVp and 10 mAs for Premium Cotton Rayon is sufficient to allow the x-ray beam to pass through the material effectively to produce detailed structures except apex of the petrous temporal bone.

Other material which is Premium Valencia Satin has a similar VGA score with Premium Cotton Rayon. However, the visualisation of the listed structures from both materials differs from the observers' view. The image of Premium Valencia Satin has the optimum exposure to visualise outer and inner lamina of cranial vault. However, the exposure was insufficient to visualise the floor of the sella and apex of the petrous temporal bone as the scores were inferior to the reference image. It means that Premium Valencia Satin causes inadequate penetration into the structures of interest. This finding showed that this material has some influence on visualising a few structures in PA (0^0) skull radiograph.

Even though from observers' point of view there were few images that have degradation and improvement of image quality, the statistical test indicates there was no significant difference between each material when compared to reference image for optimum exposure. This is due to the differing perspectives of each observer, which include variations in eyesight, experience, and other factors (Johari, 2014). Individual differences such as the acuity of vision, familiarity with image quality assessment, and subjective interpretation of image details all contribute to the varied perceptions. The inconsistency may result from the assessors and the factors that mentioned above may effect on how the assessors evaluate the images (Sharipudin, 2015).

Consequently, while some observers might perceive an improvement in image quality, others might see degradation, leading to inconsistent evaluations. Therefore, it can be concluded that the presence of Premium Chiffon Georgette, Premium Cotton Rayon and Premium Valencia Satin on a phantom in PA (0^0) skull examination does not have any effects on radiographic image quality. In other words, patients should be allowed to wear a hijab of these three materials during skull examinations without compromising the accuracy of diagnosing pathologies.

Comparison Of the Radiographic Image Quality For Each Hijab Materials (Premium Chiffon Georgette, Premium Cotton Rayon and Premium Valencia Satin) Using Different Tube Potentials Energy

When exposed with various exposure factors (low, optimum and high), there are some effects between Premium Valencia Satin at optimum exposure and Premium Valencia Satin at high exposure factors. It can be due to the different penetration power when the exposure factors are increased. In contrast, Premium Chiffon Georgette and Premium Cotton Rayon does not have any effects in radiographic image quality when exposed with various exposure factors. It means that patients wearing this kind of materials are not required to remove the hijab during the examination. Based on the findings, 61.5 kVp and 20 mAs is optimal for PA (0^0) skull examination as most of the radiographic images have high image quality compared to other exposure factors.

There are few limitations in this study. First of all, Kyoto Kagaku phantom does not have any vascular channels. Therefore, assessors were having difficulty when giving the scores for the visualisation of vascular channels as outlined in the VGA form. The phantom only shows the bony cortical outline which is not listed in the form. Hence, for future recommendation, it is suggested to do it on the real patient and human skull. It is because phantom usage is limited to visualise certain structures and lacks pure soft tissues and bony structure. Therefore, it is recommended to conduct this research on structures that have similar characteristics to the human skull in order to get accurate data such as bovine skull.

Moreover, there is no previous study about the effects of image quality for different hijab materials in skull examination. Researcher can just review related journals in order to have an understanding of the predicted outcomes. It appears to have numerous uncertainties and contributed to several limitations and have also led to new findings and discoveries. Additionally, there are limited studies on the attenuation coefficients of various materials, making it challenging to determine which materials have high attenuation and which have low attenuation.

This study was conducted using various kVp and mAs settings. Therefore, for future recommendations, it is suggested to keep the mAs constant rather than varying its value. With a fixed mAs, any changes in image quality can be attributed to variations in other parameters, such as kVp or the type of material being imaged, allowing for

more accurate and reliable comparisons. If the kVp is changed while the mAs remains constant, the effects on image quality will be more accurate and assessable.

Overall, this study successfully achieved the primary objectives of investigating image quality by wearing different types of hijabs. By demonstrating that the three hijabs used did not affect image quality, this study supports the practice of allowing patients to maintain their modesty without compromising the quality of radiographic images. This also can preserve the aurah of female patients during skull examinations and fulfilling Allah's obligation. This is consistent with the concepts of dignity and respect in medical practice, ensuring both religious observance and excellent patient care. Both men and women should conceal their aurah from being seen by others. Hence, it is recommended that radiographers should not ask patients to remove their hijabs before the examination, as the hijab does not affect image quality. Radiographers should preserve the patient's privacy such as aurah, especially for female Muslim patients, while also ensuring excellent radiological practices to optimise image quality.

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