THE EFFECT OF DIFFERENT JUBAH DRESS' MATERIALS ON IMAGE QUALITY USING COMPUTED RADIOGRAPHY (CR) ON KNEE X-RAY: A BOVINE STUDY

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ABSTRACT

Introduction: In medical imaging practice, the act of removing any clothes from the region of interest is justified as to prevent the presence of artefacts on radiographs. However, by doing so, the 'aurah' of the patients, especially for the Muslims, are not observed and can be considered as violating their privacy if they are not well-informed beforehand. Previous studies have proved that radiographs with the presence of some fabric materials on the region of interest are radiographically acceptable. Therefore, the aims of this study are to tackle the issue of exposing one's 'aurah' for a knee x-ray examination to take place and also to add insufficiency from the previous studies. **Methods:** The effect of three different jubah dress' materials; heavy dull satin, high quality lycra and moss crepe on radiographic image quality for both anteroposterior (AP) and lateral knee x-ray examinations are evaluated. The effect on radiographic image quality by the manipulation of tube potentials on each jubah dress' materials are also evaluated. A bovine's knee is used to simulate human's knee as opposed to previous studies which only utilized KYOTOKAGAKU phantom. Four experienced observers blindly graded image quality using Visual Grading Analysis (VGA). **Results:** This study shows that all three of the jubah dress' materials produce no artefacts on images and at the same time, present no significant effect on radiographic image quality. The manipulation of tube potentials on each jubah dress' materials also equally gives the same result. However, some increment to tube potentials is recommended to improve image quality. **Conclusions:** It can be concluded that a knee x-ray examination can be done without the need to remove either heavy dull satin, high quality lycra or moss crepe.

KEYWORDS: *Jubah Dress, Image Quality, Computed Radiography, Bovine, X-ray, Knee*

INTRODUCTION

In medical imaging practice, all radiopaque objects should be removed carefully from the radiographic field of interest to prevent artefacts from interfering with the quality of diagnostic imaging. The standard procedure is to ask the patient to remove the clothing before putting on a hospital gown, which commonly has the opening in the back (Bontrager & Lampignano, 2010). However, only limited studies have been done in assessing the actual effects of fabric materials and their diagnostic acceptability on plain radiographs.

Through the study by Hasbullah (2013), it has been proved that even though the use of fabrics during x-ray examinations do give artefacts on images, the radiographs are still deemed acceptable by radiologists. In 2014, from the study of fabric materials and image quality by Johari (2014), it has been reported that the presence of sports trouser gives rise to artefacts but the image is still accepted. The image is accepted as the artefacts are minimal and do not compromise the diagnostic image values.

Nowadays, patients are more well-informed about their right and privacy. In medical imaging, one of the commonly asked questions is for the purpose of clothes removal as part of patient's preparation. Patients may question if they regard them as unnecessary exposure to one's body part. It has been documented in Patient Charter adopted by the United Kingdom in 1995, besides protection of privacy, the patients also have the right to be educated before and after the examination takes place (WHO, 2016). Therefore, it is needed for radiographers to justify the act of exposing one's body part in x-ray examination.

According to Islam, 'aurah' is the parts of the human body that must be covered by any pieces of clothes. Covering the 'aurah' is not a choice but it is an obligation to all Muslims as Allah S.W.T has command to do so (Anonymous, 2014). The concept of preserving 'aurah' is crucial among Muslim community and therefore, together with patient's right to general privacy, it should also be taken into consideration before exposing one's body part for any diagnostic examinations. In practice, for knee x-ray examination, patients are usually requested to remove their trousers even though only the knee area is needed to be radiographed (Johari, 2014). This shows that the matter of covering one's aurah is taken lightly by radiographers in Malaysia, even when the fact remains that, the majority of the community are Muslims.

As phantom cannot be considered to represent the pure human's soft tissues, thus, a number of authors have suggested another study to be done using bovine as simulation (Hasbullah, 2013; Johari, 2014). Johari (2014) has stated that the result of using other material that is the nearest to mimic human structures in the study can be directed to real life situation.

Giridharan, Kumar and Muthusamy (2000) wrote in his article that the results from animal experiments can be applicable to human. This is because animal and human have much similar biological systems. Similarly, several studies have been conducted using bovine as research models especially in surgical field (Limpert, Desai, Kumpf, Fallucco & Aridge, 2009; Pohamac & Aflaki, 2010). Thus, it gives an idea that a bovine can be used as a substitute of human's bone anatomy.

Therefore, this study will tackle the two main issues in preserving 'aurah' as discussed above; interpretation of the different type of fabric materials on x-ray images and application of a bovine as the research model. In summary, three different jubah dress' materials that are commonly worn will be used on the bovine knee to study their effects on image quality for knee x-ray examinations.

METHODS

Pilot Study

Pilot study was done objectively to identify the optimum technical factors that could produce acceptable image because the standard antero-posterior (AP) and lateral knee x-ray technical factors could not be used as bovine's leg had different thickness than standard human. The pilot study also was done to evaluate whether the use of plastic food wrapper around the bovine's leg could give rise to artefact or not.

The bovine's leg was exposed with different peak kilovoltage (kVp) and miliamperage-seconds (mAs) by trial and error until optimum exposure was acquired. Radiograph with sharp bony cortical outline and well-visualized bony trabeculae pattern were used as indicator of choosing optimum exposure and as evidence of no artefact.

Image Acquisition

The bovine was positioned for AP knee x-ray examination. The region of interest was collimated to include knee, one-third distal femur and one-third proximal tibia fibula. The bovine was exposed without any jubah dress' materials using 85 kVp with constant 8 mAs. The image served as the reference images.

The steps were repeated with heavy dull satin, high quality lycra and moss crepe on and each material was exposed using the same exposure setting as the reference images. No crease was made in certain during the placement of material on the bovine's leg to avoid any artefacts. The whole procedures were repeated for lateral knee-xray projection using 75 kvp with constant 5.6 mAs.

Image Evaluation

Radiographic image quality was evaluated using Visual Grading Analysis (VGA) system. The images were blindly evaluated by four assessors; two radiographers from Unit Pengimejan Diagnostik, Hospital Bentong, Pahang and two radiographers from Department of Diagnostic Imaging and Radiotherapy, Kulliyyah of Allied Health Science, International Islamic University Malaysia (IIUM) Kuantan with than five-year clinical experiences in the medical imaging field.

Each score given by the assessors were calculated using Equation 1 adapted for Tingberg (2005). The image with the highest average score was proved to have the best image quality and conversely, an image with the least score was considered to have poorest image quality.

$$\text{VGAS} = \frac{\sum G}{I \times S \times 0} \qquad \text{Equation 1}$$

Where,
G = Grading (-2, -1, 0, +1, +2) for the image I, structure S and observer O
I = Number of images
S = Number of structures
0 = Number of observers

Data Analysis

Radiographic image quality was compared between individual jubah dress' materials for both AP and lateral knee x-ray examinations. Simple bar charts were used to represent the data from VGA scores. The score of VGA was obtained by comparing the test image with respective reference image. Descriptive analysis from the bar chart was used to study the effect of jubah dress' materials on radiographic image quality.

Statistical Analysis was done using Statistical Package for Social Sciences (SPSS) version 12.0.1 for Windows. Data of the study was considered as a non-parametric test since the random sampling and normality assumption were not met. SPSS tests were conducted to show if there was any significance difference in image quality. First, Kruskal-Wallis test was used to compare the effects of different types of jubah dress' materials on bovine model and radiographic image quality for both AP and lateral knee x-ray examinations. Second, Mann-Whitney U test to test for differences between different jubah dress' materials for both AP and lateral knee x-ray examination. P-value which is less than 0.05 ($p<0.05$) indicates that there is significance difference in the study for both tests. Third, Intra-Class Correlation Coefficient (ICC) test was used to evaluate intra-observers agreement using Two-Way Random effect model for absolute agreement. ICC value can be interpreted as; 0 - 0.2 = poor agreement, 0.3 - 0.4 = fair agreement, 0.5 - 0.6 = moderate agreement, 0.7 - 0.8 = strong agreement and > 0.8 = almost perfect agreement. The results of VGA scoring can be referred in Appendix A, while the statistical results can be referred in Appendix B.

RESULTS

The VGA scores in Figure 1 above showed that heavy dull satin displayed an increase in the score when compared to the reference image as the VGA score obtained was >0. For high quality lycra and moss crepe, both materials showed a decrease in scores when compared to respective reference images as the VGA score obtained were <0. It could be seen that, in AP knee x-ray examination, the presence of heavy dull satin on AP knee x-ray examination gives better radiographic image quality compared to other two materials. The result from Kruskal-Wallis test showed that the significant level was 0.368 in which the p-value >0.05. The result suggests that there is no significance difference in image quality for different jubah dress' materials used.

1. VGA Score between Individual Jubah Dress' Materials for AP Knee X-Ray Examination

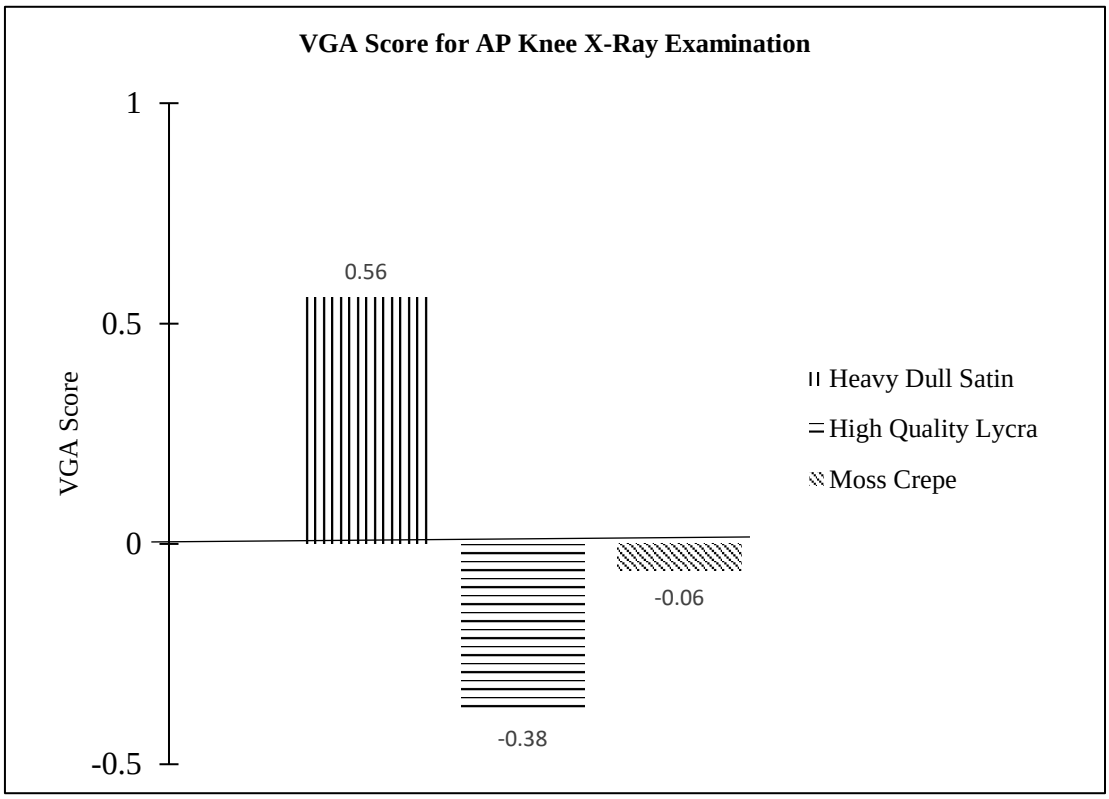

Figure 1 VGA score acquired from Heavy Dull Satin, High Quality Lycra and Moss Crepe for AP knee examination

Mann-Whitney U test showed that the significant level was 0.317 in which p-value >0.05. The result suggests that there is no significance difference in image quality between heavy dull satin and high quality lycra, between heavy dull satin and moss crepe and between high quality lycra and moss crepe. Through statistical analysis, it is found that there is no significance difference between three jubah dress' materials due to the very small sample size. On the contrary, descriptive analysis has proved that heavy dull satin gives better radiographic image quality as compared to the reference image and other two materials.

A strong level of agreement on image acceptance between observers is indicated by the ICC value of 0.70 (with 95 percent confidence interval). In a simpler word, all three images are deemed radiographically acceptable. This shows that the hypothesis is accepted as there is no effect on image quality of knee radiograph with three different jubah dress' materials on AP knee x-ray examination.

VGA scores in Figure 2 above showed that Moss Crepe and High Quality Lycra had an increase in scores compared to reference image as the VGA score obtained were >0. For heavy dull satin, it showed no difference between the image quality of test image and the reference image as the VGA score =0. It could be seen that, in lateral knee examination, the presence of both moss crepe and high quality lycra give better radiographic image quality compared to heavy dull satin. The result from Kruskal-Wallis test showed that the significant level was 0.368 in which the p-value >0.05. The result suggests that there is no significance difference in image quality for different jubah dress' materials used.

2. VGA Score between Individual Jubah Dress' Materials for Lateral Knee X-Ray Examination

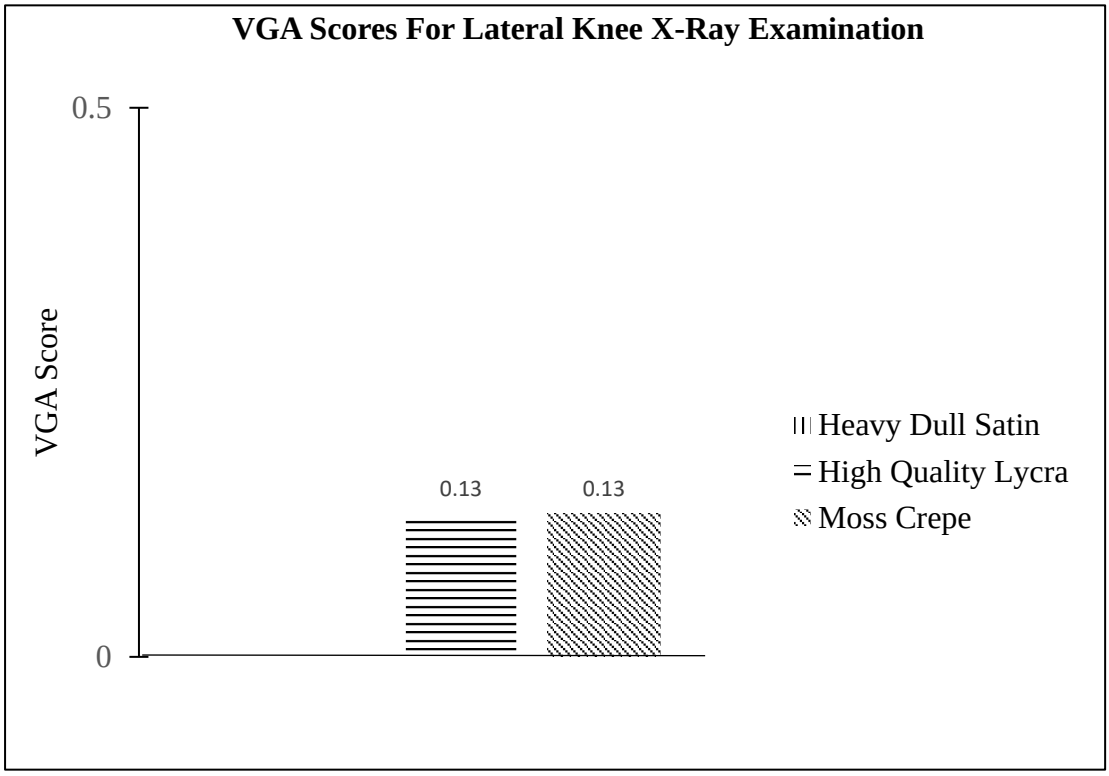

Figure 2 *VGA score acquired from Heavy Dull Satin, High Quality Lycra and Moss Crepe for lateral knee examination*

Mann-Whitney U test showed that for the group heavy dull satin-high quality lycra and heavy dull satin-moss crepe, the significance level were 0.317, while for the group high quality lycra-moss crepe, the significance level was 1.00 The p-value of each group was >0.05. The result suggests that there is no significance difference in image quality between heavy dull satin and high quality lycra, between heavy dull satin and moss crepe and between high quality lycra and moss crepe.

Through statistical analysis, it is found that there is no significance difference between three jubah dress' materials due to the very small sample size. On the contrary, descriptive analysis has proved that high quality lycra and moss crepe give better radiographic image quality as compared to the reference image and heavy dull satin.

A perfect level of agreement on image acceptance between observers is indicated by the ICC value of 1.00 (with 95 percent confidence interval). In a simpler word, all three images are deemed radiographically acceptable. This shows that the hypothesis is accepted as there is no effect on image quality of knee radiograph with three different jubah dress' materials on lateral knee x-ray examination.

DISCUSSION

1. AP Knee X-Ray Examination

From the result, it can be seen that heavy dull satin shows the highest VGA score when compared to high quality lycra and moss crepe. Even though statistically, it has been shown that these different jubah dress' materials are not significant enough to have differences, all images are deemed acceptable by observers. Thus, it can be concluded that radiographic image quality will have no effect with the presence of jubah dress' materials for AP knee x-ray examination.

From observers' point of view, the presence of heavy dull satin, high quality lycra and moss crepe do not give any artefacts on the image. They express the opinion that the contrast and density are adequate to demonstrate the surrounding soft tissues and bony structures of the knee. It concludes that the penetration and exposure are adequate even when heavy dull satin is placed on the bovine's knee. This finding shows an x-ray of patient's knee with heavy dull satin on the region of interest will produce no artefacts.

All images with the presence of those three jubah dress' materials have been accepted with a strong level of agreement by observers. These results further supported by Mohamed Nadzri (2011) which stated that an image is accepted when the contrast and density are adequate as the bony trabeculae pattern and bony cortical outline are well-visualized.

2. Lateral Knee X-Ray Examination

It can be seen from the result that both high quality lycra and moss crepe have high VGA scores while heavy dull satin has the same image quality as a reference image. As similar to the above result, it can be concluded that the presence of any three jubah dress' materials on lateral knee x-ray examination do not degrade the image quality.

Even though statistically, it has been shown that these different jubah dress' materials are not significant enough to have differences, all images are deemed accepted by the observers. It can be concluded that radiographic image quality will have no effect with the presence of jubah dress' materials for lateral knee x-ray examination.

From the observers' point of view, heavy dull satin, high quality lycra and moss crepe do not give any artefacts on the images. They agree that the image quality of the test images and reference image are the same. It is because the anatomy in the region of interest; bony trabeculae patterns and cortical outlines of the distal femur, proximal tibia and fibula, patella and the knee joint of the test images are well visualized as the reference image. This finding shows that an x-ray of patient's knee with those three jubah dress' materials on the region of interest will produce no artefacts.

All images with the presence of those three jubah dress' materials have been accepted with the perfect level of agreement by observers. Mohamed Nadzri (2011) stated that an image is accepted when the contrast and density are adequate as the bony trabeculae pattern and bony cortical outline are well-visualized.

Therefore, it can be concluded that for each different jubah dress' materials used on a bovine for both AP and lateral knee x-ray examination, there is no change to radiographic image quality. The presence of materials also give no artefacts on images and all images are radiographically acceptable. These findings of current study is consistent with previous study by Hasbullah (2013) and Johari (2014).

CONCLUSION

This paper set out to determine the radiographic acceptability for knee x-ray examination when three different jubah dress' materials are x-rayed together with knee in order to simulate the concept of covering aurah during radiographic procedure.

Since both AP and lateral examinations scores shown no significance differences statistically and radiographically acceptable by the all assessors, it can be concluded that the presence of jubah dress' materials on knee have no effect on image quality of knee radiograph. Taken together, these results can suggest as scientific proof that allowing Muslim patients to adhere to their obligations without compromising the radiographic image quality.

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REFERENCES

Anonymous. (2014). Understanding the obligation of 'hijab' in Islam — Nisar Mohammad Ahmad. Themalaymailonline.com: http://www.themalaymailonline.com/what-you-think/article/understanding-the-obligation-of-hijab-in-islam-nisar-mohammad-ahmad (Accessed on 07-05-2016)

Bontrager, K. L., & Lampignano, J. P. (2010) Textbook of Radiographic Positioning and Related Anatomy. USA:Elsevier, Mosby

Cesar, L. J. (1997). Computed Radiography: Its Impact on Radiographers. *Radiol Technol.* 68(3):181-5

Gridharan, N. V., Kumar, V., & Muthusamy, V. (2000). Use of Animals in Scientific Research. *Indian Council of Medical Research*. Ministry of Health & Family Welfare: New Delhi.

Hasbullah, W. S., (2013). The Effect of Headscarf Fabric to Radiographic Image Quality in Standard Computed Radiography for Posteroanterior (PA) Chest X-Ray. *Unpublished Thesis*. International Islamic University, Kuantan, Pahang.

Johari, J. K., (2014). The Effect of Different Fabric Materials on Radiographic Image Quality using Computed Radiography (CR) on Knee X-Ray. *Unpublished Thesis*. International Islamic University Malaysia, Kuantan, Pahang

Limpert, N. J., Desai, A. R., Kumpf, A. L., Fallucco, M. A., & Aridge, D. L. (2009). Repair of Abdominal Wall Defect with Bovine Pericardium. *The American Journal of Surgery, e60-e65*

McQuillen, M. K. (2011). Radiographic Image Analysis (3rd Ed.). Saunders Elsevier Inc.: USA

Pohamac, B., & Aflaki, P. (2010). Use of Non-Cross-Linked Porcine Dermal Scaffold in Abdominal Wall Reconstruction. *The American Journal of Surgery,* 22-27

Shetty, C. M., Barthur, A., Kambadakone, A., Narayanan, N., & Kv, R. (2011). Computed Radiography Image Artifacts Revisited. *American Journal of Roentgenology (AJR).* 196:W37-W47

Tingberg, A. (2005). Evaluation Of Image Quality Of Lumbar Spine Images: A Comparison Between FFE And VGA. Radiation protection dosimetry. 144:53-61.

World Health Organization. (2016). Patients' Rights.: http://www.who.int/genomics/public/patientrights/en/ (Accessed on 14-04-2016)

APPENDIX A

Table of Visual Grading Analysis (VGA) Result for Antero-posterior (AP) Knee X-Ray Examination

Criteria	Heavy Dull Satin			High Quality Lycra			Moss Crepe		
	85 kVp	99 kVp	73 kVp	85 kVp	99 kVp	73 kVp	85 kVp	99 kVp	73 kVp
Visualization of bony cortical outline of thin structure	2	-1	1	-1	0	-1	0	1	1
Visualization of bony cortical outline of thick structure	2	-1	1	-2	-2	-2	0	1	1
Visualization of bony trabeculae pattern of thin structure	2	-1	0	-1	-1	-1	-1	1	2
Visualization of bony trabeculae pattern of thick structure	3	-1	1	-2	-1	-1	0	1	2
TOTAL VGAS	0.56	-0.25	0.19	-0.38	-0.25	-0.31	-0.06	0.25	0.38
Image acceptance (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of artefacts (yes/no)	No	No	No	No	No	No	No	No	No

Table of Visual Grading Analysis (VGA) Result for Lateral Knee X-Ray Examination

Criteria	Heavy Dull Satin			High Quality Lycra			Moss Crepe		
	75 kVp	87.5 kVp	64.5 kVp	75 kVp	87.5 kVp	64.5 kVp	75 kVp	87.5 kVp	64.5 kVp
Visualization of bony cortical outline of thin structure	0	0	0	0	1	1	0	1	0
Visualization of bony cortical outline of thick structure	0	0	0	0	2	1	0	0	0
Visualization of bony trabeculae pattern of thin structure	0	0	0	1	1	1	1	1	0
Visualization of bony trabeculae pattern of thick structure	0	0	0	1	1	1	1	0	0
TOTAL VGAS	0	0	0	0.13	0.31	0.25	0.13	0.13	0
Image acceptance (yes/no)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of artefacts (yes/no)	No	No	No	No	No	No	No	No	No

APPENDIX B

STATISTICAL RESULTS FROM SPSS

Statistical Result within Individual Jubah Dress' Materials for AP Knee X-Ray Examination

Kruskal-Wallis Test	**VGA**
Chi-Square	2.000
Df	2
Asymp. Sig.	.368

Mann-Whitney U Test	**VGA**
Mann-Whitney U	.000
Wilcoxon W	1.000
Z	-1.000
Asymp. Sig. (2-tailed)	.317
Exact Sig. [2*(1-tailed Sig.)]	1.000(a)

Intraclass	**95% Confidence Interval**	**F Test with True Value 0**

	Correlation(a)	Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.700(b)	.136	.975	8.000	3.0	6	.016
Average Measures	.875(c)	.323	.991	8.000	3.0	6	.016

Statistical Result within Individual Jubah Dress' Materials for Lateral Knee X-Ray Examinatio

Kruskal-Wallis Test	**VGA**
Chi-Square	2.000
Df	2
Asymp. Sig.	.368

Mann-Whitney U Test	**VGA**
Mann-Whitney U	.500
Wilcoxon W	1.500
Z	.000
Asymp. Sig. (2-tailed)	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000(a)

	Intraclass Correlation(a)	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	1.000(b)	.	.	.	3.0	.	.
Average Measures	1.000(c)	.	.	.	3.0	.	.