مقارنة جودة التصوير الإشعاعي (بين الأفلام الزرقاء والأفلام الخضراء في التصوير الطبي بالأشعة السينية)

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medical x_ray imaging, radiographic films(blue and green),processor radiographic films.

ملخص الدراسة:

الهدف من هذه الدراسة هو إجراء مقارنة بين أنواع الأفلام الطبية المختلفة المرتبطة بطريقة المعالجة والتي سوف تكون بين الأفلام الزرقاء والأفلام الخضراء المستخدمة في التصوير الطبي بالأشعة السينية وأيضا الحصول على أفضل صورة إشعاعية من خلال تقييم أو استخدام عوامل التعرض المتغيرة (المعاملات أو البارامترات الأمثل) مثل الكيلوفولت والملي أمبير ووقت التعرض والمسافة المرتبطة بخاصية الفيلم وتم اختبار العديد من هذه المعاملات أو العوامل وتم تحديد أفضل عامل تعريض من خلال الفحص البصري للصورة الإشعاعية.

ستوضح هذه الدراسة الاختلافات في جودة الصورة الإشعاعية من خلال معالجة الأفلام (أليا ويدويا) عن طريق اختبار فانتوم الصدر RMI بقيمتين مختلفتين من الكيلوفولت(kVp) وعدة قيم من الملي أمبير (mAs). ومن النتائج وجدنا عند اختبار الأفلام الزرقاء أوتوماتيكيا (معالجة تلقائية) نجد أن kVp عند 50 ،60 مع mAs عند 10 ،3.2 على التوالي تظهر جودة صورة شعاعية مقبولة أي كلاهما يظهر جودة صورة مرضية نوعا ما علي الأفلام الزرقاء وبعد ذلك وفقا لتلك الإعدادات يتم اختبار الأفلام الخضراء وإنتاج الصورة تلقائيا, وعند ضبط الفيلم الأخضر عند 50kvp و10 mAs، أظهرت النتائج صورة جيدة مقارنة ب 60kvp و 3.2mA .] وهذا يدل على أن هناك بعض الاختلافات بين الأفلام الزرقاء والخضراء (التي تتكون من شاشتين مكثفتين (أمامية وخلفية) توفران أقصى انبعاث داخل المنطقة الطيفية الخضراء عند تعرضها لإشعاع الأشعة السينية). فيتميز الفيلم الأخضر بأداء عال مما يعني أن محتوى الفضة في الأفلام الحساسة للأخضر أقل منه في الأفلام الحساسة للزرقة، وهذه هي المزايا الرئيسية للأنظمة الحساسة للأخضر علي الأنظمة الحساسة للأزرق]. لذلك أظهرت النتائج أن 50 كيلو فولت و10 ملي أمبير هو الإعداد المناسب لهذا الفيلم (الأخضر) وأما 60kvp

و 3.2 mAs فتعطي نتائج التعرض المفرط للأفلام الحساسة، مما يؤثر سلبا على جودة الصور وبالتالي يظهر أن هناك ملاءمة أكثر لاستخدام شاشة حساسة للأخضر ذات قدرة تحليل عالية وحساسية متوسطة. وعند تكرار هذه العملية باستخدام المعالجة اليدوية مازال الفيلم الأخضر يعرض النتيجة الجيدة مقارنة بالفيلم الأزرق.

ومن قياس الكثافة الضوئية لكل من المعالجة الآلية واليدوية للأفلام الزرقاء والخضراء أظهرت النتائج أن كلما زاد سمك البرسبيكس زادت الكثافة الضوئية لتدرج الهواء ؛ لأن الوسط الوهمي أرق . هذا يعني أن حزمة الأشعة السينية المرسلة التي سيتم وصولها على الفيلم ستزداد مع زيادة سماكة وتدرج الهواء بسب انخفاض سماكة الوسط الوهمي . وبالتالي فإن زيادة حزم الأشعة السينية المرسلة تجعل الكثافة الضوئية أعلى ، وذلك ؛ لأن سماكة البرسبيكس تجعل تفاعل الأشعة السينية بينهما أقل .وفي النهاية من النتائج والأشكال وجدنا أن الأفلام الزرقاء والخضراء تظهر كثافة بصرية مختلفة، فتختلف الكثافة البصرية لهذين النوعين من الأفلام عن بعضها البعض ومن هنا يظهر الفيلم الحساس الأخضر التلقائي أو الأوتوماتيكي قيمة كثافة بصرية منخفضة مقارنة بالأفلام الحساسة باللون الأزرق، بينما تظهر النتائج اليدوية أن الكثافة البصرية الحساسة للأخضر تعطي قيما أعلى مقارنة بالأزرق. ويظهر اللون الأخضر صورة جيدة ؛لأنه يحتوي على هاليد فضي منخفض مقارنة بالفيلم الأزرق الحساس وهذا يتسبب في أن الفيلم الأخضر الحساس يظهر أداء جيدا. وفي النهاية وجدنا أن تقنية المعالجة التلقائية تكون أفضل طريقة للحصول على أفضل جودة للصورة مقارنة بتقنية المعالجة اليدوية والتصوير باستخدام آلة الأشعة السينية KXO-50S/K5 هو أفضل جهاز تصوير.

Comparison of the Radiograph Quality between Blue Films and Green Films in Medical X-ray Imaging

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Abstract:

The aim of this study is to make a comparison between the different types of medical films associated with the treatment method, which will be between the blue films and green films that used in medical x-ray imaging and also to obtain the best radiographic image by evaluating the optimal parameters such as

(kVp, mAs),exposure time and distance. Related to property of the movie and many of these parameters or factors were tested in this experiment.

This study will explain the expected differences in radiographic image quality from different machine and different film processing (automatic and manual) by means of the RMI chest phantom was tested by two different values kVp and several mAs. From the obtained result, it shows that the kVp at 50 and 60 are shows good radiograph quality with mAs 10 and 3.2 respectively, both of them show satisfying image quality on the blue films. while green film at setting 50 kVp and 10 mAs showed good image compare to the 60 kVp and 3.2 mAs. And it shows that 50 kVp and 10 mAs is suitable setting for this film. For 60 kVp and 3.2 mAs gives results in overexposure of green-sensitive films, which has an adverse effect on the quality of images. Thus it is shows that there are more expedient to use a green-sensitive screen with high resolving power and medium sensitivity. Next, these experiments are repeated by using different processing. Manually, green film still shows the good result compare to the blue film as same as result automatically.

After that, the optical density is measured for both manual and automatically processing for green and blue films. From the results that it shown the thickness of Perspex is increased and the optical density for air stepwedge also increased. This happens because as the thicker air stepwedge thickness, the less x-ray beam will be attenuated due to the thinner the phantom medium. This means the transmitted x-ray beam that will be reached on the film will increase as the thickness of the air stepwedge increased due to the decreasing of the phantom medium thickness. Consequently, the

increasing of the transmitted x-ray beams brings the optical densities become higher. This is because the less thickness of the medium phantom makes the interaction of the x-ray between them are less. From the figures(6,5) blue and green films are showing that automatic processing shows a greater optical density rather than the manual. Besides, from the figures(5,6) the optical densities of these two different types of films are also different to each other. From here, the automatic green sensitive shows low optical densities value compare to the blue sensitive films while the manual, the green sensitive optical densities show higher values compare to the blue one. The green shows higher optical densities because it contains low silver halide compare to the blue sensitive film and this cause the green sensitive film shows a good performance. At the end we get the auto processing technique is found to be the best method to obtain the best quality image compare to manual processing technique. The imaging using conventional x-ray machine KXO-50S/K5 is found to be better imaging equipment.
***Keywords* :** Blue films, Green films, Medical x-ray imaging .

1. Introduction

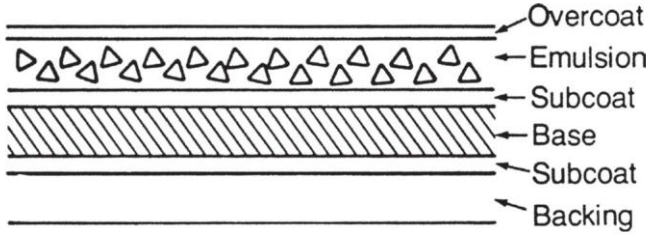
1.1Radiographic Film

In medical radiography, many products have been designed to offer a vast array of speed levels and contrasts appropriate for the body part being radio graphed. Generally speaking, the film's inherent speed depends on the silver halide crystal (grain) size, structure, and sensitivity, the choice of developer, the time and temperature that the film is processed. It naturally follows that the larger the silver halide crystal, the faster the speed of the film and the less the exposure. Combinations of different-sized crystals are used to create the desired characteristic curve, a measurement that describes the relationship between radiographic exposure and optical density.[6][15]

The layers of an x-ray film and their functions are as follows:

- **Overcoat**: A protective layer that aids in scratch protection both before and after processing
- **Emulsion**: The light-sensitive layer, made up of silver halide suspension in a high-grade gelatin support
- **Sub coat**: A very thin coating that ensures adherence of the emulsion to the base support
- **Base support**: The material that forms the structural support onto which the other sensitive and protective layers are coated
- **Backing**: Another gelatin layer sometimes used to prevent curl, inhibit light piping, and improve image quality or to act as a filter to make the film insensitive to certain wavelengths.[17]

The two primary types of radiographic film are direct exposure film and screen film. Direct exposure film provides a sharp image of thin body parts having high subject contrast. However, long exposure time is necessary to create an image with appropriate optical density. Direct exposure film was primarily employed to assess the extremities but has been widely replaced with faster high-detail film/screen combinations.[6]



Cross section of x-ray film.

Figure 1:Cross section of x ray film

[https://www.google.com/search?q=xray+film+types&tbm=isch&ved=2ahUKEwje79XPtuHtAhUDYxoKHZ0OB_oQ2-]

1.2 Types of X- ray Films :

1.2.1 On the Basis of Photosensitive Emulsion Layers:

Single Coated : in such type of x-ray films the photosensitive emulsion is coated only on one surface of film base .These films are used with single intensifying screen cassette with the film placed in front of the screen , i.e. on the side facing the x-ray tube. These pose films used when higher spatial resolution of image is desired.

Double Coated: these are routine purpose x-ray films having photosensitive coating on both sides of base and used with double screen cassette with the film sandwiched between the screens. Such films require lesser exposure factors and lesser processing times. For example the image can be produced in 1/2 the time required to produce an image on the single sided film. [17],[18]

1.2.2 On the Basis of Use with Intensifying Screen:

Screen Films: these films are used along with intensifying screens and are therefore ultimately exposed by light and not the x-rays. these films require lesser exposure factors and processing time for development of radiographic image. The emulsion coating of such films is also thinner. Such films are versatile and used for most general purpose diagnostic radiography.

Non –Screen Films :these films are used without intensifying screens and require more exposure factors and prolonged processing time for production of comparable radiographic density to that of non – screen films. They have relatively thicker emulsion and therefore radiographic image formed on such films have excellent details. Such films are used for specific purposes such as detection of hail-line fracture or any subtle tissue change that remains unrecognized in traditional routine radiograph.[17]

1.2.3 On the Basis of Types of Light Sensitive Emulsion Coating:

- Blue light sensitive films.
- Green light sensitive orthochromatic films.
- Red light sensitive panchromatic films.

The spectral sensitivity of the film must be matched to the emission spectrum of the intensifying screen in order to increase the sensitivity of the system. The principle emission from traditionally used calcium tungstate intensifying screens is blue light. Therefore, it is imperative that the films to be used with such intensifying screens must be sensitive more towards blue light. The photographic emulsion containing silver bromide is coincidently cream colored that absorbs ultraviolet and blue light, but reflects green and red light and therefore such films have been used without any problem with calcium tungustate intensifying screens.[18]

However many rare earth intensifying screens principally emit greener lights and therefore , x-ray films to be used with such screens should be made sensitive to greener spectrum of light as well. For this suitable dyes are added in their photosensitive emulsion of the films. (such green light sensitive orthochromatic films also require suitable change in x-ray darkroom safe light color and intensity) .[18][9]

1.2.4 On the Basis of Film Speed :

Film speed refers to the relative sensitive of x-ray film to a given amount of radiation. Faster films require lesser exposure but produce grainy images that lack definition. They also have narrow film latitude. Speed wise x-ray films may be categorized as following:

- Standard or par speed films.
- Fast speed films.
- Ultrafast films.

1.3 Handling and Storage Care of Unexposed and Exposed x-ray Films:

1. Films should be stored in cool(10-20°c) and low humidity (40-60%) environment.
2. Film boxes should be kept vertically without any pressure on them.
3. Films should never be stored near a source of heat , irradiation or water .
4. Films should be loaded and unloaded from a cassette on a dry and clean bench inside the dark room under a proper safe light.
5. Films should be handled delicately and any accidental splashing of processing solutions should be avoided.
6. Films should not to be used after their expiry period.
7. If an x-ray film has been exposed , the cassette should immediately be transferred to the darkroom or in a lead shielded box to avoid inadvertent subsequent exposure particularly in cases where serial radiography is being done.
8. The wet processed film should be kept up right its in a film drier for drying.
9. The wet films should never be touched with fingers to avoid fingers marks over films.[7,8]

2. Objective

To obtain the best quality radiograph by evaluating the optimum parameters such as kVp, mA, exposure time and distance associated with the film characteristic and make comparison for different film type used associated with the processing method.

3. Materials

1. RMI Radiography Chest Phantom.
2. IME-100L Inverter type mobile x-ray equipment.
3. X-ray Machine, Toshiba KXO-50S/K5 .
4. SRX-101A Medical Film Processor.
5. Cassette Konica Minolta KR-118 x 10 in.
6. Radiographic Film AX(Konica Minolta) 20.3 x 25.4 cm (8x10in).
7. Radiographic Film MG(Konica Minolta).
8. RMI Densitometer.

Figure 2 : RMI densitometer and Radiographic film processor system SRX-101A.

Figure 3: Perspex chest phantom and x-ray machine.

4. Procedure

1. The RMI Radiographic phantom with the stepwedge on the bottom was placed on the x-ray table.
2. The edges of the phantom are cone and an exposure taken.
3. SID was set to 100 cm.
4. The AX film was exposed with some variable exposure technique.
5. The film was processed by using automatic processor.
6. Film image was evaluated under the luminescent box and the test object that will be seen in the film will be recorded.
7. Step 1-6 was repeated using various techniques setting to optimize the detection of the test objects and the various techniques setting which give the best show of the test object is recorded.
8. The quantitative measurement for bone and the air stepwedge densities is taken by using RMI densitometer.
9. The optical density readings are recorded.
10. The graph for optical density versus the relative thickness of air stepwedge is plotted for the manually process and automatically process x-ray film.

11. The structures that can be seen in the image are observed and the result is recorded. The size of location of the test object or location of the test objects visible and the detail of an appropriate qualitative comment about visibility of the test object are recorded.

5. Results and Discussion

5.1 Phantom description using X-ray Machine, Toshiba KXO-50S/K5 (Automatic processing):

5.1.1 Blue Film:- √ visualized , − not visualized

SID (cm)	kVp	mAs	Phantom descriptions				
			Bone stepwedge cavities		Air stepwedge		2 steel sphere
			0.5 mm deep	1.0 mm deep	hemisphere	cylinders	
100	50	10	2	2	4	4	√
		7.2	1	2	5	5	√
		5	1	1	5	5	√
		3.2	1	1	5	5	√
100	60	10	2	4	3	2	√
		7.2	3	4	4	4	√
		5	2	2	4	4	√
		3.2	1	1	5	5	√

Table1: Phantom description using X-ray Machine (Automatic processing) for bone and air stepwedge .

SID (cm)	kVp	mAs	Phantom descriptions							
			AlO_2 specs				Barium			
			1.9 mm	1.4mm	1.0mm	0.8mm	5%	10%	20%	40%
100	50	10	√	√	√	−	√	√	√	√
		7.2	√	√	√	−	√	√	√	√
		5	√	√	√	−	√	√	√	√
		3.2	√	√	√	−	√	√	√	√
100	60	10	−	−	−	−	−	√	√	√
		7.2	√	√	−	−	√	√	√	√
		5	√	√	−	−	√	√	√	√
		3.2	√	√	√	−	√	√	√	√

Table 2: Phantom description using X-ray machine (Automatic processing) for AlO_2 specs and Barium .

SID (cm)	kVp	mAs	Phantom descriptions				
			5 steel spheres	Fat mimicking cylinders			½ vertebra
				12.7 mm	9.5 mm	6.3 mm	
100	50	10	√	√	√	√	√
		7.2	√	√	√	√	√
		5	√	√	√	√	√
		3.2	√	√	√	√	√
100	60	10	√	–	–	–	√
		7.2	√	√	√	–	√
		5	√	√	√	–	√
		3.2	√	√	√	√	√

Table 3: Phantom description using X-ray machine(Automatic processing) for Fat mimicking cylinders.

SID (cm)	kVp	mAs	Phantom descriptions									
			Tumors				Al Spheres					
			3.5 mm	2.25 mm	1.5 mm	0.75 mm	7.9 mm	6.4 mm	4.8 mm	3.2 mm	2.3 mm	1.5 mm
100	50	10	√	√	√	√	√	√	√	√	√	√
		7.2	√	√	√	–	√	√	√	√	√	√
		5	√	√	√	√	√	√	√	√	√	√
		3.2	√	√	√	–	√	√	√	√	√	√
100	60	10	–	–	–	–	√	√	√	√	√	–
		7.2	√	√	–	–	√	√	√	√	√	√
		5	√	√	√	–	√	√	√	√	√	√
		3.2	√	√	√	√	√	√	√	√	√	√

Table 4: Phantom description using X-ray machine(Automatic processing) for Tumors and Al Spheres.

5.2 Phantom description using (Green) Film (Automatic processing)

5.2.1 Green Film:-

SID (cm)	kVp	mAs	Phantom descriptions				
			Bone stepwedge cavities		Air stepwedge		2 steel sphere
			0.5 mm deep	1.0 mm deep	hemisphere	cylinders	
IME-100L	50	10	1	1	5	5	√
	60	3.2	1	1	5	5	√

Table 5: Phantom description using X-ray Machine (Automatic processing) for bone and air stepwedge.

X-ray Machine	kVp	mAs	Phantom descriptions							
			AlO_2 specs				Barium			
			1.9 mm	1.4mm	1.0mm	0.8mm	5%	10%	20%	40%
IME-100L	50	10	√	√	√	–	√	√	√	√
	60	3.2	√	√	√	–	√	√	√	√

Table 6: Phantom description using X-ray machine (Automatic processing) for AlO_2 specs and Barium

X-ray Machine	kVp	mAs	Phantom descriptions				
			5 steel spheres	Fat mimicking cylinders			½ vertebra
				12.7 mm	9.5 mm	6.3 mm	
IME-100L	50	10	√	√	√	√	√
IME-100L	60	3.2	√	√	√	√	√

Table 7: Phantom description using X-ray machine(Automatic processing) for Fat mimicking cylinders.

X-ray Machine	kVp	mAs	Phantom descriptions									
			Tumors				Al Spheres					
			3.5 mm	2.25 mm	1.5 mm	0.75 mm	7.9 mm	6.4 mm	4.8 mm	3.2 mm	2.3 mm	1.5 mm
IME-100L	50	10	√	√	√	√	√	√	√	√	√	√
IME-100L	60	3.2	√	√	√	–	√	√	√	√	√	√

Table 8: Phantom description using X-ray machine(Automatic processing) for Tumors and Al Spheres.

5.3. Phantom description using blue and green film (Manual processing):

50 kVp, 10 mAs, SID = 100 cm , Manual(50kvp,10mAs):-

Film	Phantom descriptions				
	Bone stepwedge cavities		Air stepwedge		2 steel sphere
	0.5 mm deep	1.0 mm deep	hemisphere	cylinders	
Blue	1	2	3	3	√
Green	1	1	5	5	√

Table 8: Phantom description using blue and green film for bone and air stepwedg.

Film	Phantom descriptions							
	AlO_2 specs				Barium			
	1.9 mm	1.4mm	1.0mm	0.8mm	5%	10%	20%	40%
Blue	√	√	–	–	√	√	√	√
Green	√	√	√	√	√	√	√	√

Table 9: Phantom description using blue and green film for AlO_2 specs and Barium.

Film	Phantom descriptions				
	5 steel spheres	Fat mimicking cylinders			½ vertebra
		12.7 mm	9.5 mm	6.3 mm	
Blue	√	√	√	√	√
green	√	√	√	√	√

Table 10: Phantom description using blue and green film for Fat mimicking cylinders

Film	Phantom descriptions									
	Tumors				Al Spheres					
	3.5 mm	2.25 mm	1.5 mm	0.75 mm	7.9 mm	6.4 mm	4.8 mm	3.2 mm	2.3 mm	1.5 mm
Blue	√	√	√	–	√	√	√	√	√	√
green	√	√	√	√	√	√	√	√	√	√

Table 11: Phantom description using blue and green film for Tumors and Al Spheres.

√ visualized , – not visualized

5.4.Optical Density(OD):-

Step	Blue Film		Green Film	
	Automatic	Manual	Automatic	Manual
1	2.17	1.96	1.13	1.51
2	2.25	2.03	1.39	1.9
3	2.51	2.07	1.68	2.05
4	2.66	2.17	1.91	2.52
5	2.72	2.2	2.14	2.75

Table 12:optical density (OD) for blue film and green film

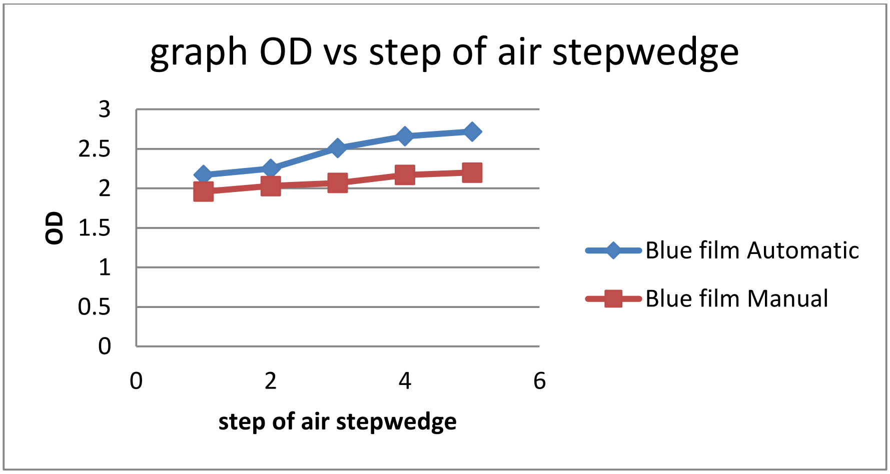


Figure 5: Graph of OD versus air stepwedges for Blue film

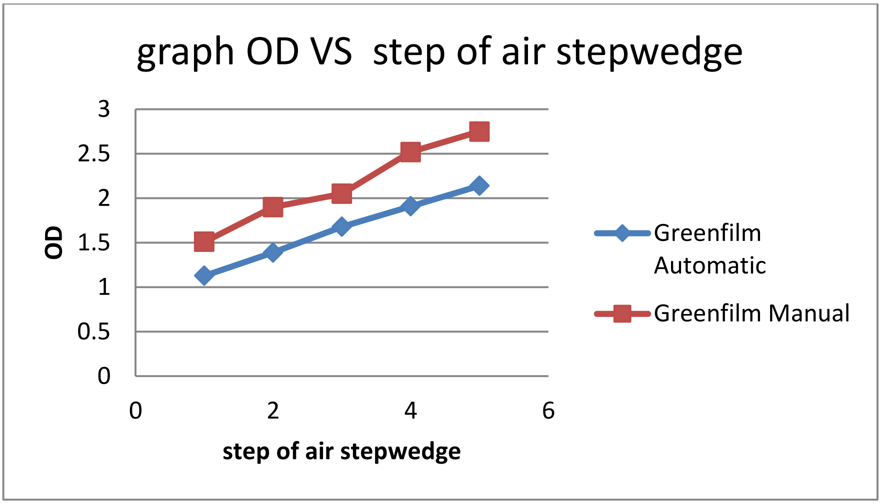


Figure 6: Graph of OD versus air stepwedges for Green film

From the result the quality radiograph was good and the comparison between different types of films there are not much different between them.

6.Discussion

There are a lot of factors that may effects on the quality of the radiograph performance. kVp and mAs, cassette properties, film or screen selection, use and properties of a grid are the examples of these factors which effect the radiograph quality. Several of these factors are tested on this experiment. Tables 1 until 8, the RMI chest phantom was tested by two different values kVp and several mAs. From the obtained result, it shows that the kVp at 50 and 60 are shows good radiograph quality with mAs 10 and 3.2 respectively. Both of them show satisfying image quality on the blue films.

Then, according to those setting, the green films was be tested and produced image automatically. From here, green film shows that at setting 50 kVp and 10 mAs showed good image compare to the 60 kVp and 3.2 mAs. There are some different between the blue and green films. Green film consists of two intensifying screens (front and rear) providing maximum emission within the green spectral region when exposed to X-ray radiation. Other than that, green film has high performance that means the content of silver in green sensitive films is lower than in blue-sensitive films and these are the main advantages of green-sensitive over blue-sensitive systems. And it shows that 50 kVp and 10 mAs is suitable setting for this film. For 60 kVp and 3.2 mAs gives results in overexposure of green-sensitive films, which has an adverse effect on the quality of images. Thus it is shows that there are more expedient to use a green-sensitive screen with high resolving power and medium sensitivity. Next, these experiments are repeated by using different processing. Manually, green film still shows the good result compare to the blue film as same result as automatically.

After that, the optical density is measured for both manual and automatically processing for both green and blue films. Figure 5 and 6 show the data for optical densities, from that it shown that as the thickness of Perspex is increased, the optical density for air stepwedge also increased. This happen because as the thicker air stepwedge thickness, the less x-ray beam will be attenuated due to the thinner the phantom medium. This means the transmitted x-ray beam that will be reached on the film will increase as the thickness of the air stepwedge increased due to the decreasing of the phantom medium thickness. Consequently, the increasing of the transmitted x-ray beams brings the optical densities become higher. This is because the less thickness of the medium phantom makes the interaction of the x-ray between them are less. From the figures(5,6) blue and green films are showing that automatic processing shows a greater optical density rather than the manual. Besides, from the figures(5,6) the optical densities of these two different types of films are also different to each other. From here, the automatic green sensitive shows low optical densities value compare to the blue sensitive films while the manual, the green sensitive optical densities show higher values compare to the blue one. The green shows higher optical densities because it contains low silver halide compare to the blue sensitive film and this cause the green sensitive film shows a good performance.

7. Conclusion

For Toshiba KXO-50S/K5 the most suitable exposure factor that gives optimum quality of image is 50kVp, 3.0mAs (50mA, 0.06s) at 100cm FFD, The exposure factor for mobile x-ray machine can be considered as 'inconsistent' as we do not know the actual value of mA and exposure time. So, the value of mA and time by the mobile x-ray might be different compare to the conventional x-ray although the same kVp and mAs were used for x-ray machine. The auto processing technique is found to be the best method to obtain the best quality image compare to manual processing technique. The imaging using conventional x-ray machine KXO-50S/K5 is found to be better imaging equipment.

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