ORIGINAL ARTICLE

USE OF SPECTROPHOTOMETER FOR DETERMINING THE OPTIMUM TIME OF DEVELOPER EXCHANGE IN RADIOLOGY DEPARTMENTS

Ali Shabestani Monfared[1], Naser Ghaemian[2], Sakineh Ghasemzade Roshan[3]

[1] Department of Medical Physics, Babol University of medical sciences, Babol-Iran.
[2] Department of Radiology, Babol University of medical sciences, Babol-Iran.
[3] School of Radiography, Babol University of medical sciences, Babol-Iran.

PJR October - December 2008; 18(4): 113-117

ABSTRACT

OBJECTIVE: To determine the optimum time for developer exchange in radiology department using spectrophotometry. **MATERIALS & METHODS:** Maximum absorption wave lengths were measured for various kinds of developer agents using spectrophotometry in last day of developer work during the last day of developer use in three hospitals. Samplings were also done from the first to last days of developer usage for hospitals and the corresponding curves were provided. **RESULTS:** Results showed that maximum absorption wavelengths are dependent on developer type and the outset of plateau part of optical density versus day of usage curves could be considered as optimum time for exchange. **CONCLUSION:** Spectrophotometry is a simple and gratis method and helps us to avoid errors in experiential determining of developer exchange time. This method doesn't need to sophisticated systems and can be simply done using a conventional spectrophotometer which can be easily found in each medical laboratory, often adjacent to a radiology department.

Key Words: Developer, Spectrophotometry, Radiology

Introduction

Despite extensive use of digital techniques in recording of medical radiography images;[1,2,3] wet chemical film processing is still common especially in developing countries. Beside this, use of wet laser printers needs chemical processing agents that altogether are still common methods for film processing in the world.[4] It is because of the fact that image quality in wet laser printers is much better than dry laser printers[5] and contains fewer artifacts.[6] The role of developer in film processing and its impact on radiograph quality is well documented.[7,8] Low image quality may cause repetition of X-ray examination which in turn leads to extra and unnecessary radiation dose to the patient and personnel. It is believed that about 90 percents of USA community dose originates from diagnostic radiology and nuclear medicine as sources of artificial ionizing radiation.[9] There are many reports indicating that the population effective dose from medical diagnostic examinations is a very important factor in estimation of risk.[10,11] A repeat analysis program in Austria showed that most of 26.7% of all films rejected and repeated were due to improper exposure and film processing problems.[12] Developer change time depends on many factors such as work load and film size and is usually determined by operator experience. Late change may reduce the image quality[13] and increase the patient and staff radiation dose due to increasing exposure techniques[14] and also may lead to X-ray tube exhaustion because of anode heating due to increasing exposure factors to compensate developer oldness or even repeating exposure.[15] On the other hand, early change is waste of resources and produces more pollution because of releasing chemicals into the environment.[16] So, determining of proper time for developer change is extremely important. The main goal of the present study is the investigation of feasibility of spectrophotometry as a simple, gratis and practical tool for determining the optimum time of developer change in radiology departments.

Correspondence : Ali Shabestani Monfared
Associate Professor of Medical Physics
Babol University of Medical Sciences
Babol-Iran.
Ph: +98 911 1230475
E-mail: monfared_ali@yahoo.com

Material and Methods

Developer samples (1 ml) of two kinds of developers from three large teaching hospitals (hospital 1 & 2 used developers manufactured by *Jahan Pardazesh Daru Chemical Industries* and hospital 3 used developer produced by *Fuka Chemical Industries*) were collected by disposable syringes at the last day of usage (just before change). All the chemicals were prepared according to the mixing and preparing instructions recommended by corresponding manufactures. Hospitals 1 and 3 used similar automatic film processing instruments (AGFA manufacture, Belgium – Replenishment rates adjusted on 25 ml/hr). Hospital 2 used another automatic film processing instrument (HOPE manufacture, USA - Replenishment rates adjusted on 35 ml/hr). The maximum absorption wave length (MAWL) was determined using calibrated spectrophotometer (Spectronix 20, UK) at room temperature. The time between sampling and analyzing was kept minimum (10 min.) to avoid developer contamination. All samples were covered by aluminum foils and Para-film from light and air exposure to prevent oxidation. Also similar sampling were done from the first to last days of developer usage with one day interval at similar time for each hospital and the Optical Density (OD) versus day of usage (D) curves were provided for corresponding MAWLs. Each sampling was repeated three times and the mean value was considered as MAWL. The first day after that, no significant increase in OD (|dy/dx|<10 in two adjacent point) was seen (outset of plateau of Optical Density (OD) versus day of usage (D) curves) was considered as optimum time for change. It was an arbitrary point on the basis of assumption that after this point the developer is nearly saturated from Bromine (Br) concentration and oxidation process of developer at this point is completed.

Results

Figures 1, 2 and 3 show the MAWLs for hospital 1, 2 and 3 respectively. As figures show the MAWL for hospital 1 and 2 which used similar developer (*Jahan Pardazesh Daru Chemical Industries*) are 410±5 and 405±5 nm respectively. However the MAWL for hospital 3 which used developer manufactured by *Fuka Chemical Industries* is 425±5 nm.

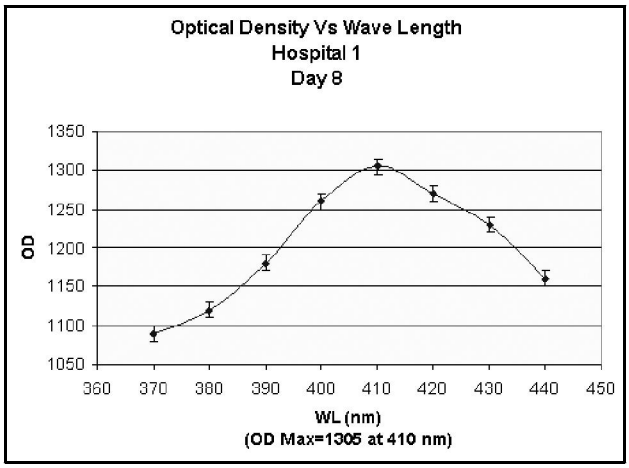

Figure1: OD Vs WL for hospital 1 at last day of usage (Day 8). Error bars show standard deviation from mean.

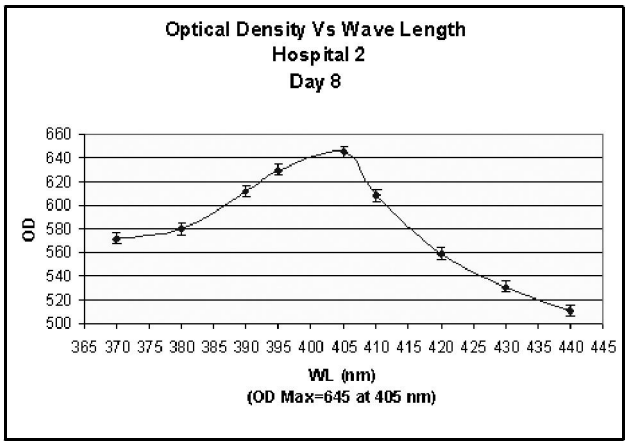

Figure 2: OD Vs WL for hospital 2 at last day of usage (Day 8). Error bars show standard deviation from mean.

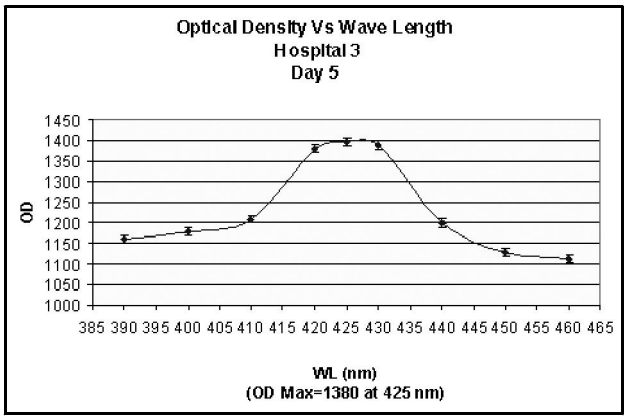

Figure 3: OD Vs WL for hospital 3 at last day of usage (Day 5). Error bars show standard deviation from mean.

The OD at the corresponding MAWL was plotted with respect to time of usage of developers in each hospital is shown in figures 4, 5 and 6. The outset of plateau part of curves was considered as optimum time for

change and found to be days 6 (OD=1280), 7 (OD=642) and 5 (OD=1397) for hospital 1, 2 and 3 respectively. As mentioned previously, we assumed that after this OD the developer is saturated from Br concentration and oxidation process of developer at this point is completed. So, the MAWL remains nearly constant after this point (|dy/dx|<10 in two adjacent point). The plateau region is marked in corresponding curves as red points.

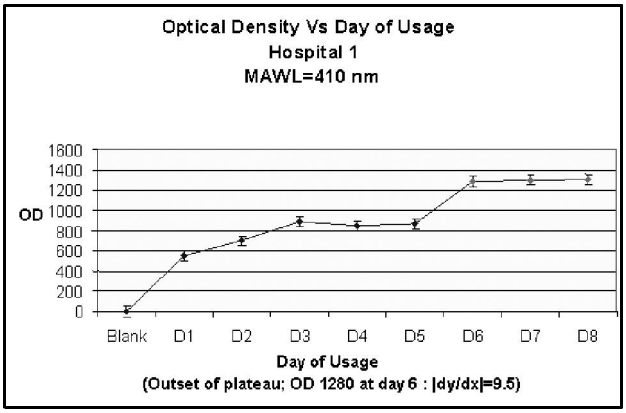

Figure 4: The OD Vs MAWL during total period of usage of developer in hospital 1. Error bars show standard deviation from mean.

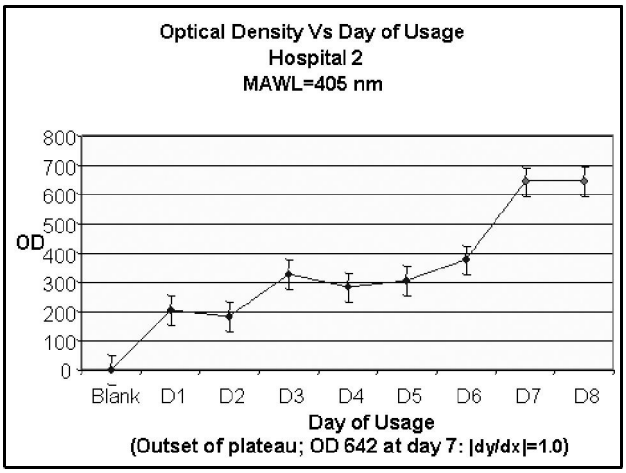

Figure 5: The OD Vs MAWL during total period of usage of developer in hospital 2. Error bars show standard deviation from mean.

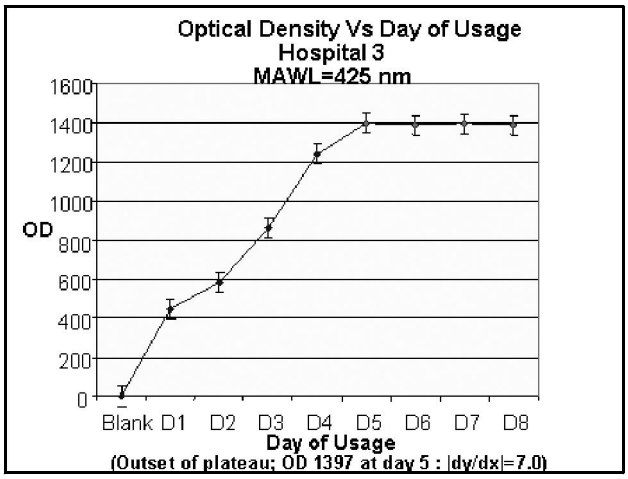

Figure 6: The OD Vs MAWL during total period of usage of developer in hospital 3. Error bars show standard deviation from mean.

Discussion

The proper change time of developer in film radiography guaranties the image quality, safe environment and reduces the patient dose as well as the radiation dose to staff.[7,8,12,14] Moreover, it is economically rewarding. Kavas and Weinberg have reported that exhausted developer affect the film speed in dental and oral radiography.[17] Thunthy et al have also reported that changing the temperature of chemical agents in automatic processing affect on the sensitometric properties of light-sensitive films.[18] Increasing the temperature for compensation of developer exhaustion may also increase its fume which in turn is harmful for radiographers' health.[19, 20, 21, 22] Although some methods such as chemical,[23] sensitometric[24] and measuring developer electrical conductivity,[25] have introduced for assaying of developer activity, use of these methods is limited due to complexity and need to special materials and sophisticated devices that are expensive and at present the change time is determined by experiential methods which is associated by human operation errors. Results of the present study showed that the MAWL depends on the type of developer. So, the MAWL should be measured for each type of developer separately. A non significant minor difference between MAWL of developers for hospital 1 and 2 might be due to various developer replenishment rates in different automatic film processing devices in corresponding hospitals. Results also show that although hospital 1 and 2 used similar type of developer, the OD for the last day of usage at similar MAWL is

not the same (1305 and 645 for hospital 1 and 2 –figure 1 and 2). This finding might be due to different type of automatic processors with different replenishment rate and different film number and sizes which were processed in those hospitals. It is interesting to note that both of these developers experientially changed at day 8 that indicate, changing regardless to work load and replenishment rate and just on the basis of operator experience, is not a good way. According to the present study the optimum date for developer change in hospital 1 and 2 was days 6 and 7 respectively. It means that developers in hospital 1 and 2 have changed 2 and 1 day later than optimum time in the present study that may lead to increasing of developer temperature and/or exposure techniques. Regarding to hospital 3, the optimum time for developer change according on the results of the present study and experiential method are concordant (day 5). It can be concluded that Spectrophotometry is an easy, fast and gratis method for determining the optimum time for developer change. This method doesn't need to sophisticated systems and can be simply done using a conventional spectrophotometer which can be easily found in each medical laboratory, often adjacent to a radiology department.

Acknowledgment

We would like to thank Ms. Alavi, Ms Sedigh and Mr. Malekzade for their assistance in preparing samples. The cooperation of Ms. Shahande and Ms. Rekabpoor for doing spectrophotometry experiments is highly appreciated.

References

1. Cowen AR, Davies AG, Kengyelics SM. Advances in computed radiography systems and their physical imaging characteristics. Clin Radiol. 2007 Dec; **62(12):**1132-41.

2. Körner M, Weber CH, Wirth S, Pfeifer KJ, Reiser MF, Treitl M. Advances in digital radiography: physical principles and system overview. Radiographics. 2007 May-Jun; **27(3):**675-86.

3. Chen, C.-N., Huang, S.-K., Hung, S.-W., Huang, S.-M., Yang, C.-W., Wen, C.-H., Lee, S.-K. The experience of accessing filmless in a medical center. Chinese Journal of Radiology. 2004, **29(5):** 253-62.

4. Seibert JA. Digital radiography: image quality and radiation dose. Health Phys. 2008 Nov; **95(5):** 586-98.

5. Schueller G, Kaindl E, Matzek WK, Semturs F, Schuller-Weidkamm C, Helbich TH. Image quality of a wet laser printer versus a paper printer for full-field digital mammograms. AJR Am J Roentgenol. 2006 Jan; **186(1):**38-43.

6. Schueller G, Kaindl E, Matzek WK, Semturs F, Schuller-Weidkamm C, Helbich TH. Validation of image quality in full-field digital mammography: is the replacement of wet by dry laser printers justified? Eur J Radiol. 2007 May; **62(2):**267-72.

7. Syriopoulos K, Sanderink GC, Velders XL, van Ginkel FC, van der Stelt PF. The effects of developer age on diagnostic accuracy: a study using assessment of endodontic file length. Dentomaxillofax Radiol. 1999 Sep; **28(5):**311-5.

8. Kimme-Smith C, Sun H, Bassett LW, Gold RH. Effect of poor control of film processors on mammographic image quality. Radiographics. 1992 Nov;**12(6):** 1137-46.

9. Ayad M. Risk assessment of ionizing radiation energy in diagnostic radiology. Applied Energy, 2000, **62:** 321-8.

10. Brugmans MJ , Buijs WC Geleins J, Lembrechts J. Population exposure to diagnostic use of ionizing radiation in the Netherlands . Health phys. 2002, Apr; **82(4);** 500-9.

11. Ludwig RL, Turner LW. (2002). Effective patient education in medical imaging: public perceptions of radiation exposure risk. Allied Health. Fall; **31(3):** 159-64.

12. Peer S., Peer R., Giacomuzzi SM., Jaschke W. (2001). Comparative reject analysis in conventional film-screen and digital storage phosphor radiography. Radiat. Prot. Dosimetry; **94(1-2):** 69-71.

13. Kircos LT, Staninec M, Chou LS. Effect of developer temperature changes on the sensitometric properties of direct exposure and screen-film imaging systems. Dentomaxillofac Radiol. 1989 Feb; **18(1):** 11-4.

14. Burns CB, Turner GW. The effect of decreased developer activity on patient exposure. Radiol Technol. 1983 May-Jun; **54(5):**391-3.

15. Zink FE. X-ray tubes. Radiographics. 1997 Sep-Oct; **17(5):**1259-68.

16. Weberling R. Dry view laser imager--a new economical photothermal imaging method. Aktuelle Radiol. 1996 Nov; **6(6):** 355-60.

17. Kavas H. and Weinberg R. Effects of developer exhaustion on Kodak Ekta speed plus , Ekta speed and Ultra – speed dental films , Oral surg Oral med Oral Pathol, 1995: 117-21

18. Thunthy KH, Hashimoto K, Weinberg R. Automatic processing: effects of temperature and time changes on the sensitometric properties of light-sensitive films. Oral Surg Oral Med Oral Pathol. 1991 Jul; **72(1):**112-8.

19. Dimich-Ward, H., Wymer, M., Kennedy, S., Teschke, K., Rousseau, R., Chan-Yeng, M. Excess of symptoms among radiographers. American Journal of Industrial Medicine, 2003,**43(2):**132-41.

20. Hewitt, P.J. Occupational health problems in processing of x-ray photographic films. Annals of Occupational Hygiene. 1993,**37(3):**287-95.

21. Gordon, M. Reactions to chemical fumes in radiology departments. Radiography. 1987,**53(608):**85-9.

22. Leacy, E., Brennan, P.C. The 'Darkroom Disease': A randomized control trial. Radiography 2002,**8(3):** 127-32.

23. Chanin M, Barnes FH. A chemical method for determining the activity of developer solutions. Radiology, 1954 Jul;**63(1):**105-6.

24. Nichols RL, Moseley RD Jr. Simple sensitometric control of developer activity. Am J Roentgenol Radium Ther Nucl Med. 1957 Jul;**78(1):**145-9.

25. Pentel L. and Hyman M. A method of assaying X-ray developer activity. Oral surg Oral med Oral Pathol. , 1967: **24:** 777-80.