

Effects of Developer Exhaustion on Sensitometric Properties of E-Speed Iopa Radiographic Films – Invitro Study

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ABSTRACT

Introduction: The field of Medicine has utilized X-Ray for diagnostic purposes more than any other fields. The application of X-rays in Diagnostic Medicine was recognized very soon after its discovery and it became an integral part in diagnostic aspects of medicine. The present study was undertaken to evaluate the performance of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort radiographic films regarding their sensitometric properties and optical density in fresh and exhausted processing solutions.

Material and Methods: 64 Kodak Ektaspeed Plus and 64 Agfa Dentus M2 Comfort radiographic films of size 2 were exposed and processed in a set of 4 with 15 films in each set of both types. All the processed films of both types were subjected to measurement of Transmittance (I) and Sensitometric properties. The values thus obtained were analyzed statistically and compared.

Results: In Fresh developer solution, both Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films behaved similarly having comparable Contrast, Speed and Latitude. By the end of second week, Kodak Ektaspeed Plus film showed a further decrease in contrast, loss of speed and increase in latitude. From 3rd week onwards, both the film behaved in a different way with Kodak Ektaspeed Plus performing better than Agfa Dentus M2 Comfort film. Both the films showed a decrease in optical densities in exhausting processing solution at the end of first, second and third weeks

Conclusion: It is suggested that under manual processing conditions, Kodak Ektaspeed Plus film could be recommended for use in fresh and exhausting solutions since it is consistent at varying stages of processing conditions, where as Agfa Dentus M2 Comfort film could be recommended to be used with Fresh solution and for a period of 2 weeks.

Keywords: Spectrophotomete; Sensitometric; Kodak Ektaspeed Plus

INTRODUCTION

Wilhelm Conrad Roentgen's discovery of X-rays in 1895 has brought various advancements in the practice of Medicine and Dentistry by yielding visualization of internal body structures. The field of Medicine has utilized this scientific wonder for the diagnostic purposes more than any other fields. The application of X-rays in Diagnostic Medicine was recognized very soon after its discovery and it became an integral part in diagnostic aspects of medicine.¹

The first Dental Radiograph was made by Friedrich Otto Walkhoff, a German dentist within 14 days of discovery of X-rays in 1895. Williams J. Morton in the year 1896, first used roll film manufactured by Eastman Kodak Co.^{2,4} The first hand wrapped, moisture proof dental film packet containing two films was released by Eastman Kodak Company in 1913. In 1940, an ultra-speed film became available.⁶ In 1981, Eastman Kodak Co.

introduced the first E speed film, the Ektaspeed which required a 50% reduction in exposure time in comparison to an ultra-speed film. Despite, the reduction in exposure time, many dentists preferred to use Ultra-speed film as Ektaspeed film showed poor image quality in Exhausted processing solutions.^{2,3,5} To overcome the disadvantages of Ektaspeed film, Eastman Kodak Co. in 1994, introduced a new E speed film Ektaspeed Plus which was found to be showing an inherent contrast and less sensitivity to Exhausted processing solutions.⁶

Similarly Agfa Gevaert Co. has introduced Dentus M2 film which was a fast D or slow E speed film and Dentus M4 film which was faster than Ektaspeed film. Recently, Agfa Gevaert Co. replaced its old Dentus M2 film with a new Dentus M2 film, which is an E speed film. Manufacturer claims that this new Dentus M2 film to have characteristics similar to Kodak's Ektaspeed Plus film.⁷

Similar specification films manufactured by different companies claim that their films vary in their sensitometric properties at different processing conditions, display better quality in poor processing conditions and less sensitive to varying processing conditions. This has resulted in an attempt of manufacturing and supplying films which are consistent at variations of processing conditions by various companies. In view of this, the present study was undertaken to evaluate the performance of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort radiographic films regarding their sensitometric properties in fresh and exhausted processing solutions.

MATERIAL AND METHODS

The current study was conducted in the Department of Oral Medicine, Diagnosis and Radiology, J.S.S. Dental College and Hospital, Mysore, with the aim of assessing the effects of exhaustion of developer solution on sensitometric properties of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort radiographic films. For the present study, 64 Kodak Ektaspeed Plus and 64 Agfa Dentus M2 Comfort radiographic films of size 2 were used. The first set of 15 Kodak Ektaspeed Plus and 15 Agfa Dentus M2 Comfort films were exposed for 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7 and 2.9 seconds. The same method was repeated for rest of the films of both types to obtain second, third and fourth sets of films with 15 films in

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each set of both types. Then the first set of exposed film of both types and one unexposed film of both types were processed in fresh processing solutions. The unexposed film was processed to measure the base Plus fog density. After processing first set of films of both types, the developing solution was depleted by processing 7 5"x12" extra oral radiographic films daily, to a total of 49 films per week. Then the second, third and fourth set of films of both types were processed in the same developing solution at the end of first, second and third weeks with the depletion of developing solution being carried out between the respective weeks as described above. All the processed films of both types were subjected to measurement of transmittance (I) using ultra violet spectrophotometer. The transmittance of films was measured individually at four different points on a film, the mean of which was considered. With the transmittance values obtained, the optical densities of films were calculated. Then, the sensitometric properties of film namely contrast, speed and latitude were measured by means of characteristic curves of respective film.

STATISTICAL ANALYSIS

The characteristic curves were obtained by plotting optical densities on Y- axis and respective Log relative exposure values on X - axis. The values thus obtained were analyzed statistically and compared between 0-1, 1-2, 2-3, 0-2, and 0-3 weeks for both the types of films and comparison was also made between both types of films belonging to their respective weeks. 't' test was used for group statistics and 2 way ANOVA for mean of optical density values of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films at different weeks were used with $p < 0.05$ as significant value.

RESULTS

In fresh processing solution (at 0 week), both Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films showed comparable optical density values and the Sensitometric properties namely Contrast, Speed and Latitude were also comparable.

In comparison to 0 week, Kodak Ektaspeed Plus film showed a decrease in Contrast, Speed and increase in Latitude at the

end of 1st week in Exhausted solutions Similarly, Agfa Dentus M2 Comfort film also showed a decrease in Contrast, Speed and increase in Latitude at the end of 1st week. At the end of 2nd week, Kodak Ektaspeed Plus film showed a further decrease in Contrast, Speed and increase in Latitude in comparison to 1 and 0 weeks. In a similar way, Agfa Dentus M2 Comfort film also showed a further decrease in Contrast Speed and increase in Latitude in comparison to 1 and 0 weeks. At the end of third week, Kodak Ektaspeed Plus film, in comparison to 0, 1 and 2 weeks, stabilized its contrast from the end of 2nd week to end of 3rd week, where as speed was further decreased and there was a minimal increase in latitude which was minimal. At the end of 3rd week, both Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films behaved differently i.e. from the end of 2nd week to the end of 3rd week, Kodak Ektaspeed Plus film stabilized its contrast where as Agfa Dentus M2 Comfort film did not show such behaviour and continued to show a further decrease in contrast. In respect to speed, both the films showed a further comparable decrease. In respect to latitude also, both the films showed a further increase, with Kodak Ektaspeed Plus film showing a minimal increase when compared to Agfa Dentus M2 Comfort film (Tables 1,2 and Figures 1-3).

At the end of 1st week, Kodak Ektaspeed Plus showed a gradual decrease in optical density (Mean = 0.788, S.D. = 0.320) in comparison to optical density at 0 week (Mean = 0.832, S.D. = 0.351). The differences in optical densities were negligible, minimal and so were statistically in significant ($p > 0.05$) but has a clinical significance in a similar way. Agfa Dentus M2 Comfort film also showed a gradual decrease in optical density (Mean = 0.683, S.D. = 0.261) in comparison to optical density at 0 week (Mean = 0.835 S.D. = 0.364). The differences in optical densities were minimal, negligible and so were statistically in significant ($p > 0.05$). At the end of second week, Kodak Ektaspeed Plus showed a constant decrease in optical density (Mean = 0.692, S.D. = 0.289) in comparison 1 week (Mean = 0.683, S.D. = 0.261) and 0 week (Mean = 0.835, S.D. = 0.364). In similar way, Agfa Dentus M2 Comfort film also showed a constant decrease in optical density (Mean = 0.651, S.D. = 0.271) in comparison to 1 week (Mean = 0.683, S.D. = 0.265) and 0

Film	Week of processing	Contrast	Speed	Latitude
Kodak Ektaspeed Plus	0	1.526	1.176 (0.070)	0.470
	1	1.285	1.111 (0.046)	0.515
	2	1.130	1.052 (0.021)	0.550
	3	1.109	1.025 (0.011)	0.570
Agfa Dentus M2 Comfort	0	1.375	1.165 (0.066)	0.440
	1	1.177	1.105 (0.043)	0.490
	2	1.067	1.042 (0.018)	0.520
	3	0.923	1.009 (0.004)	0.560

Table-1: Comparison of Contrast, Speed and Latitude of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films in different weeks

Sensitometric property	Film	N	Mean	Std. Deviation	'P' value
Contrast	Kodak Ektaspeed Plus	4	1.2625	0.1924	0.384
	Agfa Dentus M2 Comfort	4	1.1355	0.1906	
Speed	Kodak Ektaspeed Plus	4	1.0910	6.709E-02	0.384
	Agfa Dentus M2 Comfort	4	1.0803	6.912E-02	
Latitude	Kodak Ektaspeed Plus	4	0.5263	4.385E-02	0.505
	Agfa Dentus M2 Comfort	4	0.5025	5.058E-02	

Table-2: 't' test – Contrast, Speed and Latitude at respective weeks (Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films)

week (Mean = 0.835, S.D. = 0.364) The difference in values were minimal, negligible and so were statistically insignificant but it has clinical significance ($p > 0.05$). At the end of 3rd week,

Kodak Ektaspeed Plus showed a minimal decrease in optical density (Mean = 0.666 S.D. = 0.279) in comparison to 2nd week (Mean = 0.692 S.D. = 0.282), than in comparison to 1 week (Mean = 0.788 S.D. = 0.320) and 0 week (Mean = 0.832 S.D. = 0.351). Agfa Dentus M2 Comfort film unlike Kodak Ektaspeed

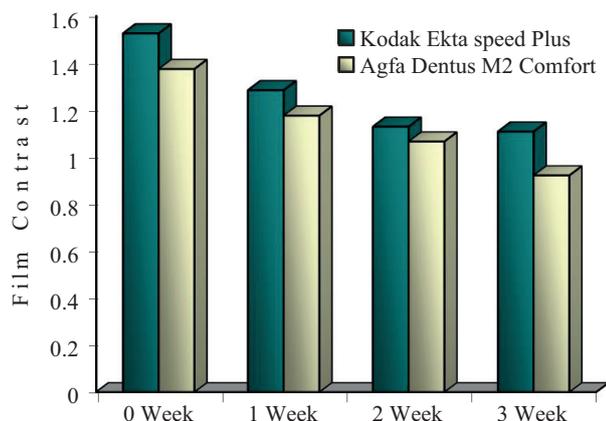


Figure-1: Film Contrast Vs Exhaustion of Developer Solution (weeks)

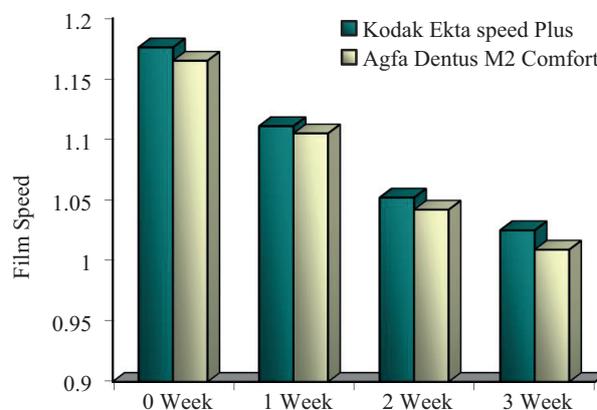


Figure-2: Film Speed Vs Exhaustion of Developer Solution (weeks)

Film	Week	Mean	Std. Deviation
Kodak Ektaspeed Plus	0	0.83227	0.35107
	1	0.78815	0.32086
	2	0.69220	0.28291
	3	0.66648	0.27940
	Total	0.74478	0.30964
Agfa Dentus M2 Comfort	0	0.83526	0.36447
	1	0.68351	0.26122
	2	0.65174	0.27111
	3	0.62799	0.26872
	Total	0.69963	0.29819
Total	0	0.83376	0.35161
	1	0.73583	0.29236
	2	0.67197	0.27303
	3	0.64724	0.27006
	Total	0.72220	0.30354

Table-3: Mean and Standard Deviation of Optical Density values of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films in different weeks

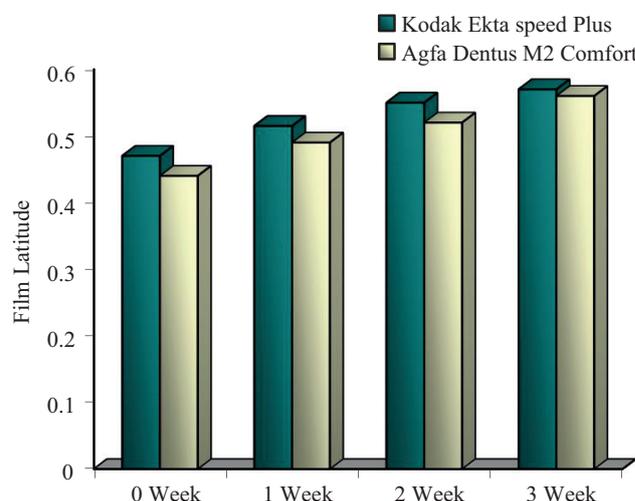


Figure-3: Film Latitude Vs Exhaustion of Developer Solution (weeks)

Week	Film	N	Mean	Std. Deviation	't' value	Df	'P' value
0	Kodak Ektaspeed Plus	15	0.83227	0.35107	-0.023	28	0.982
	Agfa Dentus M2 Comfort	15	0.83526	0.36447			
1	Kodak Ektaspeed Plus	15	0.78815	0.32086	0.980	28	0.336
	Agfa Dentus M2 Comfort	15	0.68351	0.26122			
2	Kodak Ektaspeed Plus	15	0.69220	0.28291	0.400	28	0.692
	Agfa Dentus M2 Comfort	15	0.65174	0.27111			
3	Kodak Ektaspeed Plus	15	0.66648	0.27940	0.385	28	0.703
	Agfa Dentus M2 Comfort	15	0.62799	0.26872			

Table-4: Optical Density 't' test (Group statistics)

Source	Type 3 sum of squares	Difference	Mean square	Fishers ratio (F)	'P' value
Film	6.116E - 02	1	6.116 E-02	0.669	0.415
Week of process	0.623	3	0.208	2.273	0.084
Film and week of processing	4.443 E-02	3	1.481 E-02	0.162	0.922
Error	10.235	112	9.139 E - 02		
Corrected total	10.964	119			

($p > 0.05$)

Table-5: Results of 2 way ANOVA for mean of Optical Density values of Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films at different weeks

Plus film, showed a further decrease in optical density values (Mean = 0.627 S.D. = 0.268) in comparison to 2 week (Mean = 0.651, S.D. = 0.271), 1st week (Mean = 0.683, S.D. = 0.261), 0 week (Mean 0.835, S.D. = 0.364). The difference in values were minimal, negligible and hence statistically insignificant but has clinical significance ($p > 0.05$) (Tables 3-5).

DISCUSSION

Even though the digital systems are increasingly replacing radiographic films, intraoral radiographic imaging systems are still commonly used for the purpose of carious lesion detection. In radiology, the main aim is the production of image with sufficient detail while keeping the radiation dose as low as reasonably achievable as the whole diagnostic and treatment approach further relies on this diagnostic information. Ideal X-ray film for use in day to day dental practice, irrespective of the processing conditions should produce a highly reliable image quality.⁸

In the present study, the changes in the Sensitometric properties namely Contrast, Speed and Latitude were evaluated and compared between 0-1, 1-2, 2-3, 0-2 and 0-3 weeks for Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films respectively. The comparison was also made between these two types of film at 0, and at the end of 1, 2, and 3 weeks regarding the changes in Sensitometric properties. In Fresh developer solution, both Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort films behaved similarly having comparable Contrast, Speed and Latitude. By the end of second week, Kodak Ektaspeed Plus film showed a further decrease in Contrast, loss of Speed and increase in Latitude. From the beginning to the end of 3rd week, Kodak Ektaspeed Plus film stabilized its contrast rather than decrease, both these films lost Speed further at the end of 3rd week. All these findings were in consistent with studies conducted by Thunty KH et al⁹ and Syriopoulous K et al.¹⁰

Kodak Ektaspeed Plus film exhibited a better Contrast and Speed, whereas Agfa Dentus M2 Comfort film showed better latitude at varying stages of processing. A Student's 't' test was employed to statistically analyse the changes in the Sensitometric properties. The differences in the Sensitometric properties obtained for both the films were minimal and so were statistically insignificant but it does have a clinical significance. The statistically insignificant differences in Sensitometric properties could be attributed to the more amount of processing solutions used to process the number of films taken, the less number of films used to deplete the processing solutions and the short study period employed. Even though the differences in values were statistically insignificant, however, they definitely possess a clinical significance. In the present study, both the films showed a decrease in optical densities in Exhausting processing solution at the end of first, second and third weeks. With respect to their Sensitometric properties, Kodak Ektaspeed Plus film showed a decrease in contrast till the end of second week and stabilized its contrast from the end of second week to the end of third week whereas Agfa Dentus M2 Comfort film, unlike Kodak Ektaspeed Plus film showed a further decrease till the end of third week. Both these films lost speed till the end of third week. Both these films showed a constant increase in latitude till the end of second week, but from the end of second week, Kodak Ektaspeed Plus showed a very less increase

latitude when compared to Agfa Dentus M2 Comfort film which showed a further increase in latitude. This is to say that Kodak Ektaspeed Plus film was slowly stabilizing its latitude at the end of third week where as Agfa Dentus M2 Comfort film exhibited wider latitude. Similarly, Madalli VB et al⁸ found that Kodak Ultraspeed, Ektaspeed and Agfa Dentus M2 Comfort films had comparable diagnostic accuracy in fresh solution however Ektaspeed film was inferior compared to other two films in progressively depleted processing solution. As radiation exposure is less with Ektaspeed film, thus, this should be the film of preference whenever possible.

The radiographic film is the most commonly used image receptor in both Medical and Dental Radiography. It has been the primary medium for capturing, displaying, and storing radiographic images since its inception in the late 19th century. It is the process in terms of technique and interpretation by which dentists are the most familiar and comfortable.¹¹

Various companies manufacture dental radiographic films with different specifications which differ in their Sensitometric properties at varying processing conditions i.e. in fresh and Exhausted processing solutions. Exhaustion of processing solution refers to reduction in strength resulting from number, size and type of films processed over an extended period of time. Such changes in Sensitometric properties also exist for films of same specification manufactured by different companies.

CONCLUSION

To conclude from the study, both Kodak Ektaspeed Plus and Agfa Dentus M2 Comfort intraoral periapical radiographic films showed comparable and similar changes in the Sensitometric properties in Fresh and Exhausting processing solutions till the end of second week. From 3rd week onwards, both the film behaved in a different way that is to say that Kodak Ektaspeed Plus was performing better than Agfa Dentus M2 Comfort film during this period as discussed previously. Hence it is suggested that under manual processing conditions, Kodak Ektaspeed Plus film could be recommended for use in Fresh and Exhausting solutions since it is consistent at varying stages of processing conditions, where as Agfa Dentus M2 Comfort film could be recommended to be used with Fresh solution and for a period of 2 weeks.

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