Quality of image control in Radiology Clinic using the software

Utilização de um Software no controle de qualidade da imagem na Clínica de Radiologia

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ABSTRACT

Objective
To verify the possibility of using the digital imaging as a control of the conditions of automatic radiographic processing.

Methods
Radiographic films were standardly exposed and processed, at 4 different temperatures at the beginning of the daily working of a Radiology Clinics, which were digitized and analyzed by Digora for Windows 1.5.1 software, regarding to the radiographic densities, that is, the grey level.

Results
Based on the results it was possible to conclude that there was a ranging in the grey level, because of either the processing degree of the image on the four areas evaluated of each film or at the four temperatures studied which were statistically significant. The characteristic tracings also displayed these differences and the deterioration degree of the image quality due to the consuming of the processing solution.

Conclusion
The results indicate that the evaluation of the digital image by Digora for Windows 1.5.1 software is efficient and allows the quality control of the radiographic processing properly, showing that the variation of the grey levels indicate the consuming of action of the processing solutions.

***Indexing terms**: Quality control. Software. X-ray films.*

RESUMO

Objetivo
Avaliar a possibilidade de usar a imagem digital como avaliadora das condições de processamento radiográfico automático.

Métodos
Usando filmes radiográficos expostos e processados padronizadamente, em 4 temperaturas diferentes no início dos trabalhos diários de uma Clínica de Radiologia Odontológica, que foram digitalizadas e observadas pelo software do Digora for Windows 1.5.1, quanto às densidades radiográficas, ou seja, o nível de cinza.

Resultados
As tabelas e gráficos apresentados mostram que existe uma variação do nível de cinza, seja do grau de processamento da imagem nas quatro áreas avaliadas de cada filme e nas quatro temperaturas estudadas que são estatisticamente significantes. Os traçados característicos também mostram estas diferenças e o grau de deterioração da qualidade da imagem pelo desgaste da solução de processamento.

Conclusão
Nossos resultados indicam que a avaliação da imagem digital, pelo software do Digora for Windows 1.5.1 é eficiente e permite o controle de qualidade do processamento radiográfico de forma adequada, mostrando que a variação dos níveis de cinza indicam o desgaste da ação das soluções de processamento.

Termos de indexação: Controle de qualidade. Software. Filme para raios x.

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INTRODUCTION

According to the World Health Organization (WHO),Dental radiograph is used aiming to discover, confirm, define, and locate a lesion as well as to enable an early diagnosis so that it has been considered as an important field of Dentistry and Medicine. The radiographic examination is a diagnostic method largely employed in medical areas, but it is known that x-rays can promote biological deleterious effects to the organism. Thus, it is justified the concern of the researches in reducing at most the radiation received by the patient during the image examinations used in Dentistry for diagnosis. The radiographic film mainly accounts for the reduction of radiation dosage received by the patient during a radiographic shot because when one utilizes more sensitive films, consequently the exposure time and the amount of radiation produced by the x-ray device will be decreased, diminishing at the same proportion the biological deleterious effects to both the patient and the clinician.

According to Thorogood & Horner[1], the inadequate processing of the radiographic film results in a radiographic image of low quality confirmed by the excessive number of repetition of examinations and also contributing for the increasing of the x-ray exposure for the patient. These authors affirmed that the radiographic processing must be monitored continuously and systematically, because if any failure occurs, this can lead to problems both in the image and the diagnosis. At daily basis, the Quality Control employs the sensitometer and photodensitometer which has been described as "gold standard" of the automatic processing of the films in the radiographic clinics, so that these authors suggest the construct of six graphs of following-up of radiographic processing performance.

Platin[2] described the factors involved in the Quality Control of the radiographic images based on the guidelines firstly proposed by the American Academy of Dental Radiology Quality Assurance Committee in 1983 where it had been established annual, monthly and daily controls of the materials involved in the obtainment of radiographic images. Once a year, it must be assessed the stability of the device's head, accuracy of the kilovoltage and milliamperage values, measurement of the semi reductive layer, alignment of the x-ray beam and size of the area irradiated. The cleaning of the film holders and intensifying plates, use conditions of the negatoscope and illumination of the darkroom must be verified at every month. At daily basis, it must be assessed the liquids involved in the processing and cleaning of the darkroom. The literature has reported studies on the Quality Control in Radiology, which corroborates the aforementioned information[3-10].

Oliveira[11] reported that the radiographic films and the processing solutions are mostly studied by sensitometry which consisted in the construction of characteristic curves from which the sensitometric properties of the films are obtained (contrast, latitude and sensibility). These curves are constructed from the optical density of the radiographic film and the exposure times used to sensitize the films. The optical density is assessed in the radiographs through a photodensitometer which is the traditional method demanding several readings at each exposure range of the film, by the obtainment of a mean for the further construction of the characteristic curves and their properties.

After the advent of informatics, the degree of darkening of the film can be evaluated through a digitizer by transforming the original analogical image in numerical data in a matrix of small squares so-called pixel; a number is associated to each pixel representing the image color and forming a set of number that are evaluated and stored in the computer's memory[12-17].

Silva15 conducted a research aiming to analyze the use of Radiographic Densities and inverted radiograph obtained with Adobe Photoshop 4.0 image software to replace Optical Density obtained through photodensitometers. Extraoral films (Kodak TMS-1) were exposed in sensitometer MRA for 0.5 seconds and processed at the automatic processing machine at different temperatures: 27ºC, 29ºC, 31ºC and 34ºC. These data were employed to evaluate the radiographic processing solution regarding to its activity, degradation and use in different temperatures. The results showed that the processing procedures were more efficient at the temperatures of 31ºC and 34ºC. The statistical analysis by Pearson Correlation showed high significance of the results at all temperatures evaluated regarding to the Radiographic Densities and Optical Density. The author concluded that the replacement of the conventional method by the digital method is a viable procedure when employing Adobe Photoshop 4.0 image software, with the advantage of being a more objective and faster method. Pavan[14] performed a study in which the use of Digora for Windows 1.5.1 software was verified as a tool for Quality Control because of its practical application for dental films. Also, the author verified whether the temperature increase of the processing solutions would change the image quality. It was concluded that the use of digitized images can replace the evaluation of the radiographic images performed with a photodensitometer in periapical films processed manually. The following associations: 25ºC/3 min and 35ºC/1 min, when compared with the standard pattern (20ºC/5 minutes) displayed the highest values of Optical Density, Radiographic Density and inverted Radiographic Density because the films stayed a longer time within the developing solutions than the necessary. The associations 35ºC/15s, 40ºC/15s and 40ºC/10s showed smaller values of Optical Density, Radiographic Density and inverted Radiographic Density and low image quality because they stayed a shorter time within the developing solution. The aim of this study was to evaluate the use of Digora for Windows® 1.5.1 software in obtaining Densities of Radiographic Greys, that is, the quantification of the grey levels of a radiographic film to contribute in the Quality Control of the image in the assessment of its degree of darkening aiming to make easy the monitoring the radiographic processing.

METHODS

Eighty-four extraoral radiographic films, screen type (7.5x15 cm) were used in this study, four for each processing procedure, found in Brazilian market with the following specification: Kodak TMS-1 (Kodak Brasileira Comércio e Indústria Ltd), size of 15x30cm, sold in box with 100 films, with expiration date of more than six months at the moment of the study.

The processing solution (RP X-OMAT - developing and fixing solution - concentrated liquid; Kodak Brasileira Comércio e Indústria Ltd São Paulo, Brazil) for automatic processing was used. The concentrated solutions were diluted in filtrated water up to complete 38 liters, according to the specifications of the manufacturer and prepared at the moment of the study to undergone minimal changes in their behavior and characteristics, producing images with the same radiographic qualities during all the study.

The films were exposed to light through using a sensitometer (M R A Digital, Indústria de Equipamentos Eletrônicos M R A Ltda., Ribeirão Preto, Brasil).

The data was stored in a computer (Toshiba Pentium 4, Intel 2.2 GHz, 240mB of Ram, 30GB of HD, CD and DVD reader and CD ROM 56X recorder, Toshiba Internal 1024X768 Intel® panel of 17inches), and managed by Microsoft Windows 98 software. Data processing was obtained through Digora for Windows 1.5.1.software.

A scanner (Scanjet HP 4C/T da Hewlett Packard, USA) was used to digitize and send the images to the computer with the aid of a transparency adapter which enabled the image scanning and digitizing. Inside the darkroom, in total darkness, the films were exposed in the sensitometer (MRA) for 0.5 second. The automatic processing machine (CRONEX T4) was carefully prepared within the patterns established by the manufacturer and filled with the processing solutions (RP X-OMAT. Kodak Brasileira Comércio e Indústria Ltd São Paulo, Brazil) according to the demand of radiographs of the Radiographic Discipline. The processing procedures were performed in total darkness to avoid a possible interference of the safe light leading to the total blackening of the radiographic film. The exposed films were processed either just after the change of the solutions - at the beginning of the week - or at the ending of the week, as follows: the first film at temperature of 27ºC; the second at 29ºC; the third at 31ºC and the fourth at 34ºC, respectively.

The analysis of the digital image on the computer screen was observed through Digora for Windows 1.5.1 software. To run the software, firstly, one should click on open, then examine [D:]; open the image identified as "green base film"; chose the temperature and day of the processing procedure. Next, the image appears on the screen as a rectangle containing three circles of different densities. The following parameters were utilized: film area not exposed corresponding to the base density and blackening (BDB); minimum density (Dm) in the first circle with lighter grey level; intermediary density (Di) medium grey level; and maximum density (DM) maximum grey level reached by the film.

To be visualized and determined by the Digora for Windows 1.5.1 software, the Radiographic Densities obeyed standardization so that they were repeated in programmed sequences in different moments. At the ending, 504 images had been examined and evaluated with this software.

After the reading of the densities of the grey levels, the mean and standard deviation values were obtained and submitted to statistics through one-way analysis of variance and Scheffe test (with homogeneity) and Tamhane test (without homogeneity).

RESULTS

The results corresponding to the digitized images obtained from the films regarding to their radiographic densities evaluated by Digora for Windows 1.5.1 software, were submitted to statistical analysis.

The Table 1 shows the results of the readings of the films regarding to the grey densities in Digora 1.5.1 software for 21 radiographic processing procedures at the temperatures of 27°C; 29°C, 31°C and 34°C respectively.

Figure 1 displays the graphic representation of the mean values obtained in Digora 1.5.1 software for the temperatures and exposure times, studied by the grey levels in sequence.

It can be observed in Figure 2 and 3 the characteristic tracings of the reading mean values of the grey densities obtained during the processing number 1 and 15 at the temperatures studied.

Table 2 presents the reading mean values of the grey levels of the densitometric ribbons at the temperatures of the processing procedures described, demonstrating the standard deviation.

The results showed equality among the temperatures evaluated in Table 3, which are considered as homogenous; the temperature of 34°C exhibited the best result in the processing procedures.

Table 1. Readings of the grey densities obtained by Digora 1.5.1 software, in the sensitometric ribbons digitized at the areas standardly exposed to the light of the sensitometer MRA at the four temperatures studied during the standardized processing procedures.

Sensitometric ribbons	Base density and blackening	Minimum exposure	Medium exposure	Maximum exposure
1	195	111	59	14
2	201	122	73	17
3	205	148	104	24
4	207	165	128	45
5	234	113	54	15
6	240	129	68	18
7	240	135	77	19
8	246	158	105	24
9	245	171	120	30
10	240	146	89	20
11	244	162	108	25
12	200	136	88	18
13	209	172	132	34
14	203	150	107	25
15	204	155	116	28
16	194	104	48	9
17	201	125	72	13
18	201	121	67	13
19	201	127	76	15
20	203	130	79	16
21	203	136	91	19

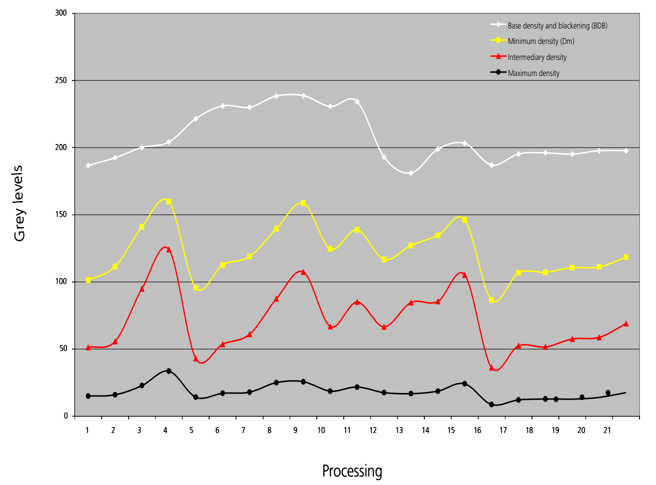

Figure 1. Graph of the means obtained in Digora 1.5.1 software at the four temperatures studied for the grey densities of the four exposure times during the standardized processing procedures sequentially.

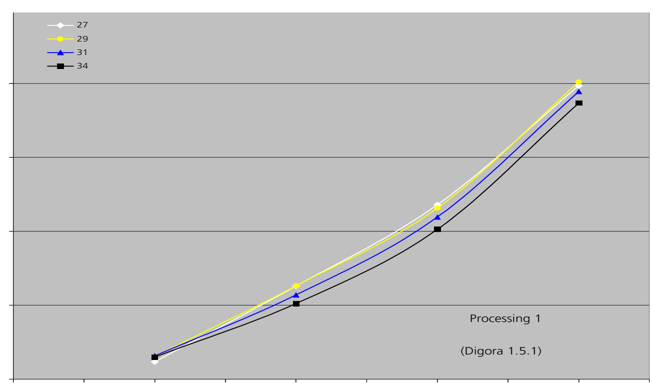

Figure 2. Characteristic tracings of the mean reading values of the grey density evaluated by Digora for Windows 1.5.1 software, for the processing procedure number #1, at the four temperature studied.

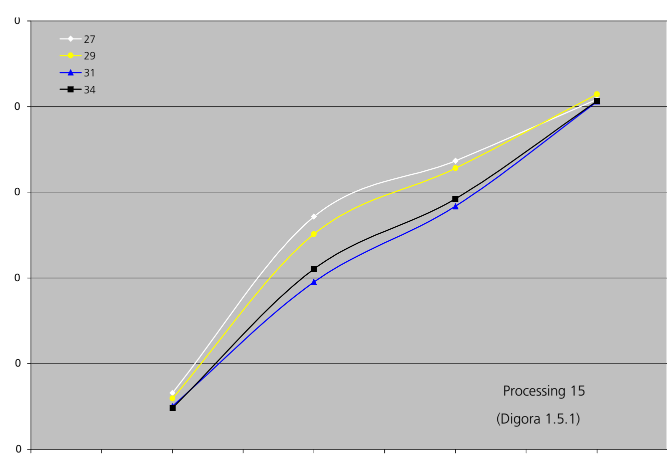

Figure 3. Characteristic tracings of the mean reading values of the grey density evaluated by Digora for Windows 1.5.1 software, for the processing procedure number #15, at the four temperature studied.

Table 2. Descriptive statistics of the reading mean values of grey levels in Digora 1.5.1 software, at the four temperatures of the processing of the digitized densitometric ribbons.

Color shade	Temperature of processing	Mean (Grey level)	Standard deviation	n
White	27°C	217,133	20,322	21
	29°C	218,547	19,724	21
	31°C	217,028	19,672	21
	34°C	207,323	18,998	21
	Total	215,008	19,843	84
Light grey	27°C	149,328	21,423	21
	29°C	147,023	22,332	21
	31°C	136,904	21,473	21
	34°C	122,247	19,813	21
	Total	138,876	23,491	84
Dark grey	27°C	99,909	26,186	21
	29°C	97,028	26,929	21
	31°C	86,128	26,334	21
	34°C	71,309	23,336	21
	Total	88,594	27,673	84
Black	27°C	20,271	10,793	21
	29°C	22,423	9,202	21
	31°C	23,152	10,833	21
	34°C	18,200	5,694	21
	Total	21,011	9,400	84
Total	27°C	121,660	74,992	84
	29°C	121,256	74,778	84
	31°C	115,803	74,159	84
	34°C	104,770	72,376	84
	Total	115,872	74,066	336

Table 3. Descriptive statistics of the reading mean values of grey levels in Digora 1.5.1 software, at the four temperatures of the processing of the digitized densitometric ribbons.

Value					
Temperature		n	Subse		
			1	2	3
Scheffe [a,b]	34 degrees	336	105.218		
	31 degrees	336		116.628	
	29 degrees	336			122.006
	27 degrees	336			122.232
	Sig.				.999

DISCUSSION

The results of our study on the analysis of grey levels of densitometric ribbons obtained by the standardized exposure in the sensitometer MRA, processed automatically in Dupont T4® and digitized for computer reading, were shown in tables and graphs. The analysis of these data will be important for evaluating the radiographic processing quality in Radiologic Clinics. Because the specialized literature lacks in guidelines on the presentation of the results obtained by this present study, it was attempted to show in Figure 1 the mean values sequence obtained in the 21 densitometric ribbons, each one representing a processing procedure, similarly to what is used in the radiologic clinics during the employment of the processing solutions. Figures 2 and 3 displays which we called "Characteristic Tracings" because they were similar to the design of the characteristic Curves traditionally used in researches on image field. The difference is that the Optical Density was not plotted in the axis "Y" and x-ray exposure was not plotted in axis "X". Additionally, the standardized exposures to light were not progressive and they cannot be plotted in logarithmic scale because the four parameters obtained (base density and blackening, minimum exposure, medium exposure, and maximum exposure) were ordered to show the darkest portions of the image at the left corresponding to dark (mean grey level from 0 to 50), followed by dark grey (mean grey level from 50 to 100), minimum exposure (mean grey level from 100 to 150), and the lightest areas around grey level of 200 corresponding to the base density and blackening, that is, the areas of the films that were not exposed to the light of the sensitometer MRA, therefore only showing the effect of the processing procedure on the emulsion of the film. In Table 1, by comparing the mean reading values of the grey levels (white, light grey, dark grey and black) analyzed in the 21 densitometric ribbons processed at the four temperatures and digitized standardly, we observed little variations which occurred because of the chemical activity (exhaustion) of the processing solutions and the usage time and amount of films processed. This can be defined as the degradation of the solutions. We noted that the processing ribbons number #1, #5 and #16 exhibited grey levels more adjusted to the image quality required by the radiograph for a correct diagnosis: mean contrast and density. The processing ribbons number #4, #9, #11, #13 and #15 showed lower quality results although adequate for the evaluation for evaluating the analogic image of the radiographic film.

The data showed in Table 1 and Figure 1 display the readings of the densitometric ribbons by Digora for Windows 1.5.1 software where it can be observed that the best quality processing procedures (#1 and #5) are seen in Figure 1 (sequential) and Figure 2 (characteristic tracings). Similarly, we observe in Figure 1 (sequential) and

Figure 3 (characteristic tracings) the data corresponding to the densitometric ribbon of the processing procedure #15 because they presented the highest discrepancies among all the results obtained so that the image exhibited the lowest quality, smallest contrast and lowest density due to either the exhaustion of the processing solutions by the amount of procedures or degradation by oxidation promoted by the time of use and contamination of other substances. The carefully observation of these characteristic tracings displays that those of best image quality are more homogenous and have a curve-like shape, beginning with the highest densities (black-50) and coming up to the lowest densities (dark grey areas-100); next, the grey level is lighter (grey level of 150), ending at the areas where the grey is even lighter, almost reaching white (grey level close to or above 200). In these processing procedures, the tracings were constant, balanced and equidistant among each other, with very close or coincident values at the maximum exposure. For the low quality images of graph 1 (sequential), corresponding to the processing procedures #4, #9, #11, #13 and #15), the tracings showed discrepancies with normal shape of a curve, ranging from upside belly-shape tracings to inverted normal curve, mainly in function of the greatest differences in relation to the medium (dark grey) and minimum (light grey) exposure. Notwithstanding, it could be noted that all tracings of the processing procedures at temperature of 34°C displayed reasonable images.

The statistical analysis (one-way ANOVA) employed the grey level as dependent variable comparing the processing temperatures and showed that the readings of the densitometric ribbons at 34°C exhibited the lowest mean values (darker grey level, due to ether longer processing or higher silver amount in the image), that is, at this temperature the most efficient processing procedure of the densitometric ribbons had occurred. Consequently, this temperature would be the most indicated at daily basis. Accordingly, the temperature of 31°C showed very close results to those of 34ºC; also, the temperatures of 29°C and 27°C can also be used.

The Post Hoc tests evaluated the differences among the mean values. Because there were no homogeneity of the variances, two test were applied: Scheffe (with homogeneity) Table 3; and Tamhane (without homogeneity). Table 3 exhibits that the temperatures of 27 and 29°C were different from 34°C, with homogeneity. The temperature of 34°C showed the best processing results, followed by 31°C.

Finally, by comparing the temperatures used in this study, it was noted that the image closest to the ideal contrast and density was obtained at 34°C; however, in most cases, this was also accomplished at 31°C. On the other hand, the temperatures of 27°C and 29°C would be not the most indicated for the processing procedures, because they only presented good results when freshly prepared.

The results of this present study corroborates those obtained by Dezotti & Tavano[7], Akdeniz & Lomçali[12], Casanova[13], Rodrigues & Tavano[17], White & Yoon[19] and Gasparini et al.[20], which tested the processing through the traditional sensitometric method. Also, the studies of Pavan[14], Silva[15], Teixeira et al.[16] and Tavano et al.[20] using informatics to evaluate the densities of the films standardly processed at the same temperatures of this present study, obtained similar results. It can be affirmed that the employment of digitalization and the reading of the image on the computer screen provides data for quality control of the radiographic processing procedures in a Dental Radiology Clinics because the digitalization of the densitometric ribbons is of ease execution with the aid of digital cameras which should be employed with caution regarding to a standardized exposure rather than the photodensitometer.

CONCLUSION

Based on the results of this present study, it can be concluded that Digora for Windows® 1.5.1 software used in the evaluation of the grey levels of the digitized densitometric ribbons was capable of discriminating the areas of exposure standardized by the sensitometer, the four temperatures employed, and the variations in the quality of the processing solutions which exhibited a certain degradation due to the intense use. The characteristic tracings graphically represent the behavior changes of the solutions employed. This is useful for the clinician to analyze what occurs during the radiographic processing and employ as Quality Control of the image, similarly to the traditional methods.

Collaborators

O TAVANO analyzed the statistical results and wrote the paper. MJ OLIVEIRA helped in the research design and collection of the data PG SILVA helped in the paper writing, developed and coordinated the research project.

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