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Quality of periapical radiographs taken by undergraduate students during endodontic treatment

Qualidade de radiografias periapicais realizadas por graduandos durante o tratamento endodôntico

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Abstract

Introduction: Correct radiographic interpretation depends on the availability of high quality images, free from technique and processing errors. Documenting the kind and the frequency of errors, as an integral part of a quality assessment program, will help to identify and to correct existing deficiencies. **Objective:** To evaluate the quality of radiographs obtained by Endodontics students from the undergraduation course of a public university. **Material and methods:** A total of 1,823 radiographs were analyzed, of which 1,408 were taken with the use of

a film-holder and 415 without it. The radiographs were made employing the same kind of film (Insight – Kodak) and of X-ray units (50 KV), with a 0.8-second exposure time, and they were processed in acrylic boxes using the visual method. With the help of a magnifying glass (2.5X) and a viewbox, three examiners analyzed the radiographs and registered errors related to the following parameters: image contrast (light or dark), vertical and horizontal angulations, positioning (film and/or radiation beam), and radiograph processing (improper fixative, stains, streaks). **Results:** Statistical analysis showed no significant differences among the examiners. The highest frequency of errors was seen in the radiograph processing, followed by the positioning and image contrast; light images were more often registered than dark ones. **Conclusion:** Considering the positioning and the vertical and horizontal angulations, the errors frequency was statistically higher in radiographs taken without a film-holder, except in the mandibular molar group, where the frequency was statistically similar in both situations.

Palavras-chave:
radiografia dental;
controle de qualidade;
diagnóstico.

Resumo

Introdução: A correta interpretação radiográfica depende da disponibilidade de imagens de qualidade, livres de erros de técnica e de processamento. Registrar o tipo e a frequência de erros cometidos e documentá-los como parte integrante de um programa de avaliação ajuda na identificação e na correção das deficiências apresentadas. **Objetivo:** Avaliar a qualidade das radiografias realizadas por alunos da disciplina Endodontia do curso de graduação em Odontologia de uma universidade pública. **Material e métodos:** Foram avaliadas 1.823 radiografias, sendo 1.408 tiradas com posicionador e 415 sem posicionador. As radiografias foram feitas com o mesmo tipo de película (Insight – Kodak) e aparelhos de raio X (50 KV), com um tempo de exposição de 0,8 segundos, e processadas em caixas acrílicas pelo método visual. Com o auxílio de lupa (2,5X) e negatoscópio, três examinadores avaliaram as radiografias e registraram erros relacionados a contraste da imagem, angulação vertical e/ou horizontal, posicionamento (da película e/ou do feixe de radiação) e processamento. **Resultados:** A análise estatística revelou não haver diferença significativa entre os examinadores. A maior frequência de erros ocorreu no quesito processamento, seguido pelo posicionamento e contraste da imagem, e imagens claras foram mais frequentes do que imagens escuras. **Conclusão:** Considerando o posicionamento e a angulação vertical e horizontal, a frequência de erros foi mais expressiva nas radiografias realizadas sem posicionador, exceto no grupo dos molares inferiores, nos quais a frequência foi estatisticamente semelhante nas duas situações.

Introduction

Periapical radiographs become extremely important in diagnosing the majority of pathologic conditions, and also indispensable in conducting endodontic treatment. The correct radiographic interpretation relies on the availability of quality images, free from technique and processing errors.

Studies have reported the kind and frequency of errors incurred when radiographs are taken and

processed by students (2-4) and by professionals as well (1, 6). Regardless of the technique employed (bisecting or paralleling), the most commonly found errors are: film and/or radiation beam positioning, image contrast (light or dark), vertical and horizontal angulations, and of processing such as, for instance, not enough fixative, and the presence of stains and streaks (2-4). Recording the frequency and the kind of errors happening in radiography practice, documenting them as the integral part of a quality

assessment program helps professors and students to identify and to correct technical deficiencies (5), cutting down the number of repetitions and exposure of patients to radiation.

The goal of the present study was to verify the type and frequency of errors occurred when periapical radiographs are taken and processed, and also to analyze the influence of the radiographed dental area and the use of a film-holder on the frequency of such errors.

Material and methods

A total of 1,823 periapical radiographs taken during the second semester of 2001 and the first semester of 2002 by undergraduate students of Endodontics in a Dentistry College of a public university were analyzed. The majority of these X-rays (n = 1,408) were taken with the help of film-holder (Hanshin), prior to treatment and also after finishing endodontic therapy. The other X-rays (n = 415), taken during treatment, were made without the film-holder. For all the radiographs the same kind of film (Insight, Kodak, New York, U.S.A) was used, with similar X-ray units (50 kV, Dabi-Atlante, Ribeirão Preto, São Paulo, Brazil), and exposure time (0.8-seconds), and processed in acrylic boxes using the visual method.

To standardize the evaluation criteria, three endodontists analyzed 20 radiographs of formerly performed treatments. The following parameters were used to analyze each radiograph:

- *Image contrast*: Light or dark image, preventing or making difficult X-ray interpretation.
- *Vertical angulation*: Lengthening and/or shortening of image.
- *Horizontal angulation*: Image overlapping, preventing or making difficult X-ray interpretation.
- *Film and/or radiation beam positioning*: Off-centered image, crown/root cut off or an area of film not exposed to radiation.
- *X-ray processing*: Improper use of fixative, existence of stains, streaks, and fingerprints.

If there was disagreement in their opinions, the examiners reevaluated the pertinent X-ray, trying to reach consensus before moving on to the next radiograph. After calibration, using a 2.5X magnifying glass and a viewbox, the three examiners analyzed individually the 1,823 study radiographs, recording on previously designed charts the occurrence of errors.

Statistical tests were used to compare inter-examiner differences (Kruskal-Wallis) and to analyze the effect in the use of the film-holder and the radiographed area exerted upon the frequency of detected errors (Chi-square), with a 5% level of significance.

Results

The frequency of errors identified by the three examiners on radiographs taken with the help of film-holders is presented on table I. Kruskal-Wallis test, used in assessing inter-examiner variation, showed no significant differences (table I). Thus, all other analyses were based on records of randomly selected examiner C.

Table I - Total number of errors detected by the three examiners (A, B, and C) on radiographs taken with the film-holder, for each of the analyzed parameters

Error	A	B	C
Light	171	171	193
Dark	69	75	71
Vertical angulation	57	57	58
Horizontal angulation	25	12	25
Positioning	554	513	532
Processing	981	948	1079
Total errors	1857	1776	1958

H value = 0.1261 and $p > 0.05$

Tables II and III present, respectively, the percentage of errors incurred on radiographs made with and without a film-holder for each of the analyzed parameters. The most frequent error was that of X-ray processing (76.6% and 73.2%, respectively), mainly regarding the presence of streaks and stains caused by incorrect use of fixative and baths.

The second greater frequency of errors incurred was that of film or radiation beam positioning, mainly in the maxillary premolars, and mandibular molars and premolars areas. Radiographs made without the film-holder showed a positioning error frequency (55.4%) significantly higher than those where the device was used (37.7%) (see table IV).

Table II - Percentage of different kinds of errors observed on radiographs taken with the use of the film-holder, as per radiographed area

Errors Area	Density		Vertical angulation	Horizontal angulation	Incorrect positioning	Incorrect processing
	Light	Dark				
*MA **(n = 295)	6.7	5.0	4.0	1.3	30.8	74.2
LA (n = 114)	10.5	4.3	7.0	0	28.9	75.4
MP (n = 247)	22.2	2.8	6.8	5.2	51	84.2
LP (n = 178)	12.9	7.8	2.8	0	44.3	77.5
MM (n = 239)	19.6	6.2	3.7	2.5	19.6	74.4
LM (n = 335)	10.7	4.4	2	0.5	46.5	74.6
Total (n = 1408)	13.7	5.0	4.1	1.7	37.7	76.6

* MA (maxillary anteriors, including canines), LA (lower anteriors, including canines), MP (maxillary premolars), LP (lower premolars), MM (maxillary molars) e LM (lower molars)
 ** (n) number of radiographs performed per area

Table III - Percentage of different kinds of errors observed on radiographs taken without the use of a positioning device, as per radiographed area

Errors Area	Density		Vertical angulation	Horizontal angulation	Incorrect positioning	Incorrect processing
	Light	Dark				
*MA **(n = 74)	5.4	5.4	20.2	1.3	33.7	63.5
LA (n = 44)	6.8	18.1	27.2	2.2	45.4	63.6
MP (n = 98)	20.4	7.1	23.4	11.2	66.3	78.5
LP (n = 42)	2.3	23.8	7.1	2.3	80.9	80.9
MM (n = 78)	32	2.5	6.4	19.2	50	75.6
LM (n = 79)	7.5	5	0	1.2	59.4	74.6
Total (n = 415)	14.2	8.4	13.9	7.2	55.4	73.2

* MA (maxillary anteriors, including canines), AI (lower anteriors, including canines), MP (maxillary premolars), LP (lower premolars), MM (maxillary molars) e LM (lower molars)
 ** (n) number of radiographs performed per area

Table IV - Results of Chi-square test for the frequency of vertical and horizontal angulation/positioning errors occurring on radiographs taken with and without the positioning device

Parameter	Figured-out values (with film-holder)	Figured-out values (without film-holder)	χ^2 value	p (%)
Vertical angulation	6.78	23.02	50.62	< 0.01
Horizontal angulation	10.79	36.61	30.74	< 0.01
Positioning	5.33	18.09	40.26	< 0.01

The third most recorded error was that of image contrast, light images being more frequent than dark ones.

Vertical angulation errors happened more often than horizontal ones, being more common on radiographs of the anterior mandible and maxillary premolar regions. Horizontal angulation errors were more often noticed in the maxillary premolar and molar areas. For both vertical and horizontal errors, the percentage was significantly greater on radiographs made without using the film-holder (table IV).

The Chi-square test was applied to compare the frequency of errors made with and without the film-holder as a function of the imaged area. In this case, density and processing errors were excluded from the analysis. When the sum of errors incurred in

the other three parameters was considered (positioning, vertical and horizontal angulation), the frequency of errors was more significant for those X-rays made without the use of the film-holder (table V), except for the area of mandibular molars where the frequency was statistically similar.

To identify the arch offering greater difficulty to be radiographed by students, the Chi-square test was used to compare the frequency of errors (angulation and positioning) incurred on radiographs of maxillary and mandibular teeth made without using the film-holder. Table VI shows that there were no differences in error frequency regarding radiographs of maxillary and mandibular anterior teeth. However, on maxillary premolars and molars, the amount of errors detected was significantly larger than that of mandibular premolars and molars.

Table V - Results of Chi-square test for the total number of vertical and horizontal angulation/positioning errors incurred with and without the use of the film-holder, as a function of the radiographed area

Area	Figured-out values (with film-holder)	Figured-out values (without film-holder)	χ^2 value	p (%)
All	15.33	52.01	81.19	**
MA	0.98	3.94	5.69	*
LA	2.64	6.86	11.27	**
MP	3.72	9.37	17.38	**
LP	2.04	8.66	13.14	**
MM	9.04	27.71	42.12	**
LM	0.27	1.15	1.72	ns

* = $p < 0.05$

** = $p < 0.01$

Table VI - Results of Chi-square test for the frequency of angulation (vertical and horizontal)/positioning errors observed on radiographs taken without the use of a film-holder, as a function of the radiographed area

Area	Angulation (vertical and horizontal)	Positioning	χ^2 value	p (%)
MA	16	25	0.04	ns
LA	13	20		
MP	34	65	6.62	< 0.05
LP	4	34		
MM	20	39	15.02	< 0.01
LM	1	47		

Discussion

Studies conducted to analyze the quality of radiographs taken by students or by professionals show the frequency of errors as being quite variable (1-4, 6). In addition to the different techniques employed in taking the radiographs (bisecting or paralleling), other factors may be responsible for the variability of results, such as the experience in taking and processing the X-ray films, the kind of X-ray units and film-holders used, and the method employed to evaluate the quality of radiographs.

For the 1,823 radiographs analyzed in the present work, 2,674 errors were detected, which means that many of the films presented more than one error. It must be observed that an existing error does not justify repeating the radiographs, unless such error prevents obtaining the required information. Although gross errors might interfere with the diagnosis and thus impair treatment, not all errors registered in the study would have such an effect.

In the present study, the most frequently incurred error was one of film processing. Obtained data seem to show that after having acquired the information necessary to carry out treatment, the students neglected the finalization of radiographic processing. Since quality X-rays are mandatory for case follow-up, and also considering the legal importance of recording every stage of endodontic treatment, it would be necessary to demand from students greater attention regarding this parameter.

Film or radiation beam positioning was the second most observed error. Similar to other studies, this error happened mainly in the maxillary and mandibular molars (1, 3, 4) and premolars (1) region, and it was significantly more common when radiographs were taken without the film-holder (table IV).

The third most frequently observed error was that of image contrast, light images being usually more frequent than dark ones, upholding early research findings (1, 6). The low contrast may result from inadequate equipment, insufficient exposure or development time. The lack of standardization of dark room procedures as well as the use of acrylic boxes and the visual method to radiographic development may have contributed to this result. In our study, it was not possible to find out the actual reason for the high incidence of light images, as in spite of having the X-ray units set to a 0.8-second exposure time; alterations introduced by the students can not be completely overlooked. Moreover, despite the type of the X-ray unit used (50 Kv) may have contributed for a high number of light radiographs, it must be pointed out that all X-ray

units used are subjected to periodic maintenance. Considering that exposure and development times are key-elements for X-ray quality, it would be interesting to enhance consideration about these issues, so as to improve image contrast.

Excessive vertical angulation was the more often registered error (18%) by Eliasson *et al.* (1), mostly in the region of mandibular anterior teeth. In the present research, even considering the excessive and the insufficient vertical angulation as one single error, the frequencies of errors in X-rays taken both with and without the film-holder (4.1% and 13.9%, respectively) were lower than that registered by those authors (18%). Similar to what was verified by Eliasson *et al.* (1) and by other authors (2-4), improper vertical angulation was more common in the lower anterior teeth area. On the other hand, horizontal angulation errors – a little more frequent on X-rays made without the help of the film-holder – were more common on radiographs of maxillary molars and premolars, areas where the dissociation of roots and/or canals, necessary to insure endodontic treatment, is usually harder to obtain. Differently from other researchers (2, 6), errors of horizontal angulation were less often detected in the present study when compared to those of vertical angulation.

According to our results, superior quality radiographs were seen when the film-holder was used. It is probable that in many instances the rubber dam, used during endodontic treatment, restrained students from correctly positioning the film or directing the radiation beam.

Finally, study results indicate the existence of errors on radiographs and their processing. The high recurrence of registered errors can be caused by various factors such as an improper teaching system, inadequate equipment, unsuitable working condition and, naturally, inattention or lack of theoretical and/or practical knowledge of students. Studies of this nature are important not only to measure students learning, but also to identify technical shortcomings and point to solutions capable of improving the teaching-learning process.

Conclusions

- 1) The most frequently seen errors were those of radiographic processing, followed by positioning (film or radiation beam) and contrast errors.
- 2) Positioning errors were more common on maxillary and mandibular premolar and mandibular molar radiographs.
- 3) Light images were more frequently obtained than dark ones.

- 4) Vertical angulation errors, more frequent than those of horizontal angulation, were more commonly seen in the mandibular anterior and maxillary premolars region.
- 5) Radiographs taken without the film-holder had significantly more errors of vertical and horizontal angulation, and of positioning, compared with those where the device was used, except for the group of mandibular molars, which had a statistically similar frequency of errors.

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