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Effect of Different Exposure Conditions and Developing Solution Concentration on the Clarity of Cervical Burnout in Bitewing Radiographs

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Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author FH managed the literature searches, managed the experimental process. Author Sajad Ghorbanizadeh analyzed the radiographs and performed the statistical analysis and ensured the scientific integrity of the study. Author Shima Golmohammadi edited and submitted the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Exposure and developing conditions can affect the occurrence of cervical burnout in bitewing radiographs which is one of the common false positive errors in these images. This study was designed to evaluate the effect of kilo voltage peak (KVP), milliampere second (mAS) and concentration of developing solution on clarity of cervical burnout in bitewing radiographs.

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Study Design: It was an experimental study performed on phantom head.
Place and Duration of Study: Department of Oral and Maxillofacial Radiology, Isfahan University of Medical Sciences in Isfahan, between August 2012 and June 2013.
Methodology: Seven bitewing radiographs were taken by XCP film holder from phantom premolars with different exposure conditions and same intensity. Then films were processed using processing solution with optimum concentration. Radiographic procedures were repeated twice under the same exposure conditions. In the first case, the films were processed by half of optimum concentration of developing solution. In the second case, the films were processed by the condition twice as concentrated as the optimum developing solution. Two oral and maxillofacial radiologists evaluated the clarity of cervical burnout. Data were analyzed using Kruskal-Wallis, Mann–Whitney U and Spearman's correlation test by SPSS software (Version 11.5).
Results: This study revealed a significant effect of exposure conditions on clarity of cervical burnout ($p<0.05$) but there wasn't any significant difference among tested concentrations of developing solution. Moreover, exposure conditions and cervical burnout clarity were significantly correlated. ($p<0.05$).
Conclusion: The use of lower contrast radiographs (high KVP and low mAs) can be useful for detecting proximal caries and preventing false positive errors like cervical burnout.

Keywords: Root caries; cervical burnout; exposure conditions; developing solution.

1. INTRODUCTION

Root caries (RC) are important phenomena according to demographic indices. However, they are not usually clinically diagnosable because of limited clinical access particularly in interproximal areas and lack of obvious color changes in initial decays. Radiographs might be regarded as valuable supplements to clinical examinations in early detection of proximal root lesions [1]. Wide proximal contacts of posterior teeth makes diagnosis of proximal carries rather difficult [2].

Bitewing radiographs are the most useful intraoral techniques in detecting proximal caries [3,4]. Radiographic detection of carious lesions is not always straightforward due to false positive interpretations as one of the main drawbacks of radiographs which might even lead to a unnecessary restoration of teeth in some cases. Among these false positive errors, cervical burnout deserves more attention as it causes more difficulties in diagnosis process [5,6]. Cervical burnout is a well-defined radiolucency on mesial or distal aspect of teeth in the cervical region between enamel edge and the crest of alveolar ridge [3]. This phenomenon can be explained by the normal configuration of tooth like narrow mesiodistal width, bell like root and lack of dense tissue between alveolar crest and cementoenamel junction which results in decreased X-ray absorption [3,5,7].

This phenomenon mostly occurs at the mesial aspect of primary and permanent maxillary molars, cervical aspect of anterior teeth, and distal surface of canines. As there is a huge similarity between proximal, cervical caries, recurrent caries and cervical burnout in some cases, detection of this phenomenon seems mandatory [5-9].

Although in some cases it is possible to distinguish cervical burnout from caries considering anatomical features or caries pathological process, but it is challenging when a metal restoration exists above the cervical region of the tooth. In these situations, distinguishing the cervical burnout from caries is impractical due to the presence of highly opaque metal collar [5]. Moreover, the coincidence of cervical burnout and proximal caries hinders the caries depth evaluation and it makes the clinician to overestimate or underestimate the actual depth of carries in some cases [7].

Automatic processing of radiographs eliminates technical and developing time errors. Though, processing errors are still one of the major causes of low quality images. The technique of developing influences the quality and diagnostic value of radiographs. Condition of exposure and developing affects the contrast and density of image. Therefore, it can affect appearance, size, and number of carious lesions being traced in a radiograph [10-13].

There are many studies that evaluate effect of exposure condition on interpretation of initial carries lesions however they did not assess false positive errors such as cervical burnout [12,14,15]. Hence the present study was

designed to evaluate the effect of kilo voltage peak (KVP), milliampere second (mAs) and concentration of developing solution on the clarity of cervical burnout in bitewing radiographs.

2. MATERIALS AND METHODS

This was an experimental study performed in the Oral and Maxillofacial Radiology department of Isfahan University of Medical Science. Exposure condition of bitewing radiographs was adjusted according to manufacturer instructions of X-ray machine (Planmeca, Helsinki, Finland) (time=0.08 s, mA=8 and Kvp=63). Based on Five percent law (5 % increase in KVP accompanied by a 30 % reduction in mAs result in the same optical density [16]) 6 more mAs and KVP conditions were defined (Table 1).

The phantom used for the present study was an anthropomorphic RANDO man phantom (laboratories of Physics Department of Tehran University, Tehran, Iran) which is equivalent to the human body in terms of X-ray absorption and scattering. Dental X-ray machine (Planmeca, Helsinki, Finland) and Ektaspeed film (Agfa-Gevaert, Mortsel, Belgium) were used to take bitewing radiographs with defined Kvp and mAs. Films were adjusted by XCP film holder (Rinn Co., USA) so that they imaged an area from mesial aspect of first premolar to distal aspect of second molar. The central ray was directed through the contact point of the mandibular first and second premolars perpendicular to the buccal surface of teeth. The tube-film distance was kept constant in all situations.

Subsequently films were automatically processed (Prepro processor, New York, USA) using processing solution (Champion, Tehran, Iran) prepared according to manufacturer instructions (normal developing).

Radiographic procedures were repeated two more times under the same exposure and geometric conditions. In the first case, the films were processed by half of optimum concentration of developing solution. In the second case, the films were processed by the condition twice as concentrated as the optimum developing solution. All stages were repeated 3 times to increase the accuracy of results.

Then two blinded oral and maxillofacial radiology specialist, surveyed all radiographs under the same condition. Two specialists evaluated the clarity of cervical burnout on mesial and distal aspect of lower first and second premolar (M4, D4, M5, and D5) and they scored each radiograph one time regarding the clarity of cervical burnout based on following scores:

0: No cervical burnout
1: Obscure cervical burnout
2: Clear cervical burnout

Radiographs were retaken if there was any sign of cone cutting or if the occlusal plan was not at the center of the film or if all contacts were not open and the alveolar crest could not be identified [5].

To assess reliability, all of examinations were repeated after two weeks and inter observer reliability was 0/99. Data were analyzed using kruskal-wallis, Mann–Whitney U test, and spearman's correlation by SPSS software 11.5 (α=0.05).

3. RESULTS

Since cervical burnouts were not observed in upper jaw, statistical analyses were just carried out on radiographs taken from lower jaw. Therefore, our results are concluded form data analysis of 84 mandibular teeth.

Furthermore, Kruskal-Wallis test revealed that for each area there is no significant difference in clarity of cervical burnout and data from all of three examinations in different developing solution were the same ($p>0.05$).

Conversely, different exposure factors (KVP, mAs) caused significant differences in clarity of cervical burnout in mesial of first premolar and mesial & distal of second premolar ($p<0.05$). Though, this was not the case for distal of first molar ($p>0.05$).

Mann–Whitney U test was used to compare difference in degrees of clarity of cervical burnout in different expose condition (See Table 1). It revealed that there was significant difference in clarity of cervical burnout in mesial and distal of second premolar between conditions number 1 & 4, 1 & 5 ($p = 0.025$), 1 & 6, 1 & 7($p = 0.034$). In mesial surface of first premolar significant differences were observed between conditions number 1 & 6, 2 & 6, 3 & 6 ($p =0.025$), 1 & 7, 2 & 7, 3 & 7($p =0.034$). Nevertheless, there was no significant difference in other conditions and surfaces (P value >0.05).

Spearman correlation coefficient disclosed the significant relation between degree of clarity of cervical burn out and exposure conditions (KVP, mAs) in general and for each tooth surface (Table 2).

According to the results of this test, it might be inferred that increasing the KVP and decreasing the mAs, reduces the degree of clarity of cervical burnout (Diagrams 1, 2).

Fig. 1 illustrates three of the bitewing radiographs taken by different KVP settings.

4. DISCUSSION

This was the first experimental study that evaluates the effect of exposure conditions and developing solution concentration on the clarity of cervical burnout. The result showed that any increase in mAs or decrease in Kvp would enhance the clarity of cervical burnout. It was also proved that any change in developing solution concentration did not significantly alter the clarity of cervical burnout.

It should be emphasized that any change in the film density due to different exposure conditions can impose noticeable effects on the caries detection ability and it also dramatically changes the rate of false positive cases. Increasing the film density will enhance the caries detection ability and also increase the false positive diagnosis. As a result, by increasing the film density, the sensitivity of the film would increase but the specificity would decrease [5,14,17]. Therefore the optical density had remained unchanged in the present study.

Table 1. Different exposure conditions defined according to 5% law

Exposure factors	1	2	3	4	5	6	7
KVP	52	55	57	60	63	66	70
mA	8	8	8	8	8	8	8
s	0.223	0.173	0.133	0.104	0.08	0.056	0.039
mAs	1.79	1.39	1.07	0.832	0.64	0.448	0.314

Table 2. Results of data analysis by Spearman's correlation test

		M4 *	D4 #	M5 §	D5 ¶	SUM ‡
KVP	r	-0.828	-0632	-0.792	-0.779	-0.811
	P-value	<0.001	0.002	<0.001	<0.001	<0.001
mAS	r	0.828	0.632	0.792	0.779	0.811
	P-value	<0.001	0.002	<0.001	<0.001	<0.001

** M4: mesial aspect of mandibular first premolars,*
 # D4: distal aspect of mandibular first premolars
§ M5: mesial aspect of mandibular second premolars,
¶ D5: distal aspect of mandibular second premolars
‡ SUM: all of the mesial and distal surfaces of first and second premolars

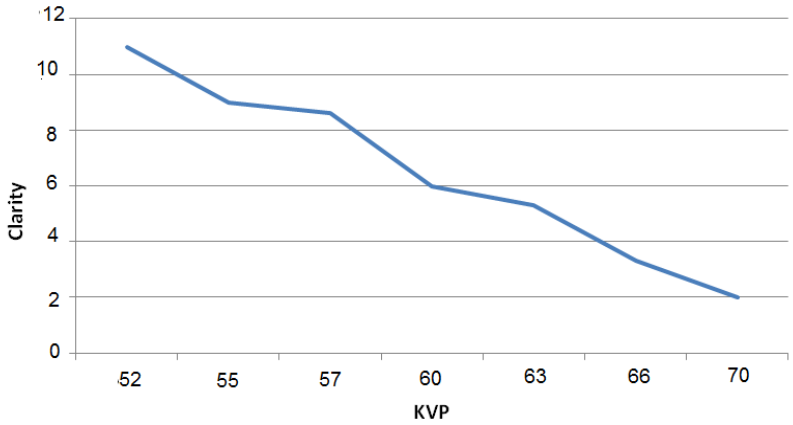

Diagram 1. Summation of clarity values for cervical burnout with different tested KVPs in mesial and distal surfaces of both premolars

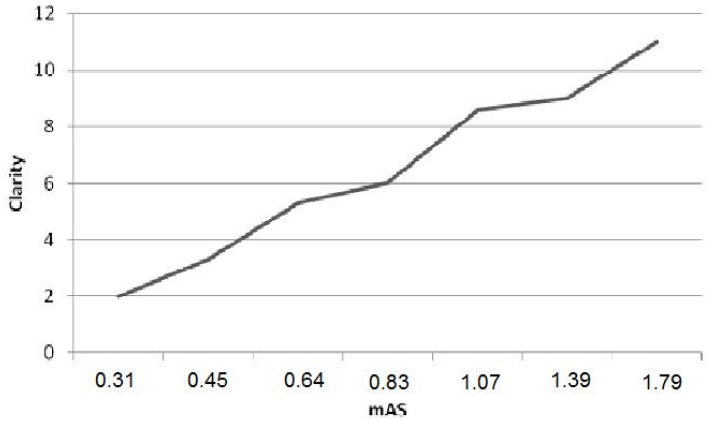

Diagram 2. Summation of clarity values for cervical burnout with different tested mAs in mesial and distal surfaces of both premolars

(a) (b) (c)

Fig. 1. The bitewing radiographs taken by KVP of a. 57, b. 63 and c. 70

The rate of cervical burnout is higher in the anterior segment. However, it is easier to distinguish this radiolucent band in the cervical region from dental carries compared to posterior segment. Thus, premolar teeth were selected for this study.

In the present study, we used intraoral radiography machine and KVP was set in the range of 50-70 which is different from previous studies that used panoramic machine to provide a KVP more than 70 in order to make proximal decays diagnosable [15]. According to Arnold et al. enhancing the KVP might reduce the clarity of cervical burnout [12]. This finding is confirmed by the results of the our study using different voltage settings.

It has already been mentioned that in order to decrease cervical burnout, we need to decrease KVP and mAs [5,8]. This is correct just when both KVP and mAs are decreased simultaneously and exposure intensities are not equal. Therefore, exposure intensity and optical density were kept constant in our study.

In this research cervical burnout has not been observed in maxilla and data analysis was only performed for the mandibular premolars. In contrast, Kuhnisch et al. [7] did not observe cervical burnout in mandible and in Rahmatulla & wyne's study, cervical burnout was more prevalent maxilla than mandible [9]. The reason for this conflict is not clear and it is suggested to use RANDO phantom in future researches to further verify the cause. Using the RANDO phantom has two main advantages. First, it models natural tissues and has been used in several radiologic studies [18]. Second, unlike some reports that have evaluated patient radiographs, the object is steady and the effect of changes in KVP and concentration of developing solutions might be more accurately assessed without the effect of other interfering variables [15].

By emergence of automatic film processors, developing time errors have diminished but there are still some problems with adjusting developing solution concentration [10]. Accordingly, this study investigated the effect of developing solution concentration among different processing errors. Since the number of tested developing solution concentrations was limited in this research and the results did not show any significant changes, new studies with more

concentrations of developing solution are suggested.

It is previously stated that the higher the KVP, the more the penetrability of the beam through soft and hard tissues. It means that enhancing the KVP would decrease object contrast and increase the film's gray scales. Moreover by decreasing mAs, the beam would be attenuated by different tissues and it can decrease the contrast. These radiographs facilitate the differentiation of different tissues. DEJ, alveolar crest and cervical aspect of teeth can be detected easily and cervical burnout would not take place [4,12]. Although the low image contrast leads to reduction in cervical burnout, it hinders the detection of minute changes like incipient proximal caries. The sensitivity of radiographs in low voltages is more due to higher image contrast but quality of images in high voltages (90 KV) does not show considerable difference compared to low voltages (60kv) and the image contrast in the range of 60-70 kVp is acceptable for image interpretation. As a result, the negative effect of high voltage on detectability of proximal caries can be neglected [12,19,20].

In addition it can be mentioned that false positive interpretations like cervical burnout can result in useless restorations that threat the teeth integrity but false negative result, especially in societies with low rate of caries is not very menacing due to low progression rate of caries [21].

5. CONCLUSION

According to the results of the present study and extrapolating the data obtained from the phantom to the human, it can be assumed that lower contrast radiographs (low KVP and high mAs) can be considered as a conservative diagnostic aid for detecting proximal caries which prevents false positive errors like cervical burnout.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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