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Optimisation of conditions of visualisation of dental crowns in dental radiography

A lot of dental and periodontal pathologies have very innocuous beginnings, with neither subjective pains that draw attention of a patient nor objective symptoms that could be detected by a dentist during a routine clinical examination (12). That is why much attention is paid to purposefulness of periodic, systematic radiological check-up of dentition. Such check-up is essential not only in diagnostic process but in monitoring of effectiveness of treatment as well as follow-up studies. However, it is crucial to apply such methods of radiological visualization that bring the lowest possible risks to patient at the same time being the most efficient ones in detection of pathological lesions (12, 16). Thus the purpose of the paper was the choice of an optimum option for evaluation of pathological lesions of dental crowns.

MATERIAL AND METHODS

There were analyzed dental intraoral images taken using the digital radiography method in the Department of Dental and Maxillofacial Radiology of the Medical University of Lublin. There were studied 985 persons, in whom there were obtained 1,491 digital intraoral X-rays by means of parallel technique (Cieszynski's technique). Among the images 1,461 were taken using a standard storage phosphor plate measuring 41x31m, while the 30 others – on a small paediatric plate. All the radiograms were obtained by means of an intraoral X-ray unit Prostyle Intra (Planmeca).

Two radiologists, a dentist trained in dental imaging and a master of electroradiology, evaluated all the images. All observers carried out the analyses independently, twice in one-month time.

For the analysis of radiological images there was applied the software of dental radiography system Digora Soredex Version 2.0. There were used the following image enhancement options: 1) negative, 2) positive, 3) pseudo-three-dimensional reformatting, 4) tomosynthesis (enhancement with one colour of all pixels having the same gray-scale value that is linear coefficient of attenuation of X-rays), 5) full colour, 6) densitometric measurements.

On all images there were evaluated such features of dental crowns as: presence of primary and secondary caries, correctness of dental fillings, occurrence of internal resorption, presence of traumatic lesions in anterior teeth and the relationship between an existing fracture line and pulp chamber as a decisive factor in clinical management. In case of large carietic defects there was also evaluated the relationship between floor of such lesions and pulp horns due to large importance in appearance of hyperemia initially followed by inflammatory and necrotic changes in pulp tissues. In case of necrotic molars with deep caries encompassing pulp chamber there was assessed the distance between the floor of carietic lesion and root furcation as such information is very important for a clinician in qualification of teeth for extraction, prosthetic or surgical and prosthetic treatment. An attempt was also made to evaluate the possibilities of differentiation between caries and radiolucent filling or liner as well as between cervical caries and cervical burn-out defects.

RESULTS

In cases of primary caries the shape of carietic destruction was best observed in negative option (Fig. 1). When secondary caries under a dental filling was suspected, densitometric measurements allowed the most accurate evaluation of pathological lesions (Fig. 2). In order to differentiate between secondary caries and radiolucent liner or filling, there were analyzed not only attenuation of the lesion but its shape as well. Also in such cases the densitometric measurements proved valuable (Fig. 3). The measurements were of use also in imaging of resorption within a dental crown.

So far as differentiation between cervical caries and cervical burn-out defects is concerned, there was taken into account the attenuation of this area of the crown in different options of digital radiography as well as the limits of the radiolucent lesion. Cervical burn-out defects were triangular (wedge-like) in shape. Their second characteristic feature was delineation from the bottom by alveolar ridge and from the top by enamel or a filling. On the other hand, the shapes of carietic lesions were irregular, not symmetrical and were found in all teeth visible on a given X-ray image. It was stated that in differen-

tiation of these defects the optimum option was negative with application of tomosynthesis function that marks out well the outlines of radiolucency (Fig. 4).

In order to assess the relation of the floor of a carietic lesion to pulp horns and to root furcation, the best method to apply was the full colour option (Fig. 5). The optimum function allowing detection of traumatic lesions of dental crowns was the pseudo-three-dimensional option (Fig. 6).

DISCUSSION

In the end of the 20th century there were introduced to dental radiology digital imaging systems, which became an alternative to conventional radiograms (3, 9, 14, 16). Currently there are two types of digital imaging systems in dental radiology (6, 15, 19). In one of them there is used a charge-coupled device (CCD), while in the other the storage phosphor (6). In the system Digora Soredex used in the presented studies there is utilized storage phosphor as a detector of ionizing radiation. Due to application of such a detector the digital radiography system is compatible with all radiological machines for intraoral radiography. Instead of a conventional X-ray film there is used a plastic registration plate covered with a layer of storage phosphor that stores the energy of X-rays. On such a plate, similarly as on a conventional film, there arises a latent image of the studied structures. However, contrary to conventional radiography, no chemical processing is required – the plate is read in a special laser scanner instead. After a short reading, the image is transferred from the laser scanner to a computer, while the registration plate is regenerated via exposure to intense visible light. Thus the plate can be reutilized, up to several thousand times, when it is mechanically used (5, 15, 16).

The obtained digital image of the studied structures can be further enhanced due to applications of options of software (4, 8, 17). They allow example changes in such image parameters as contrast and brightness, which makes even an initially imperfect image valuable for diagnosis (18). Also there is eliminated the necessity of retaking a radiogram and repeated exposure to harmful ionizing radiation is avoided (18). At the same time it should be underlined that the dose of roentgen radiation necessary obtaining an X-ray image is considerably reduced in digital radiology systems due to higher sensitivity of a radiation detector in comparison with conventional film. It is believed that sensitivity of storage phosphor plates overcomes that of charge-coupled device detectors (1, 2, 19).

Further advantages of digital enhancement of X-ray images are the possibility of their presentation in different options of software such as negative image, positive image, tomosynthesis, full colour presentation, pseudo-three-dimensional image as well as densitometric measurements. However, due to variety of pathological lesions affecting the structures of the maxilla and mandible, it becomes imperative to determine, which of the digital radiography options are of use in given pathologies and considerably increase the effectiveness of imaging and which are not helpful in given clinical cases.

On dental intraoral X-rays taken on conventional films it is possible to observe changes in hard tissues of teeth (caries, resorption) only when the decrease in content of mineral compounds building these anatomical elements overpasses 30%. Digital radiography allows an increase in sensitivity of detection of demineralization or hypermineralisation, thus implying rise in sensitivity of detection of pathological changes of teeth structures. It is vital especially in case of carietic lesions located on approximal surfaces that are difficult to reach in clinical examination (7, 11, 13, 20). There also exists the possibility of differentiation between secondary caries and radiolucent filling or liner by means of radiodensitometric measurements. When a carietic lesion is detected on clinical examination it is possible to determine the relation of the floor of such a defect to pulp horns. It is a very important piece of information for a clinician preparing the tooth for filling as large depth of a carietic lesion since in such a case there is a possibility of injury to pulp of the tooth during treatment. It is evident that such injury can be irreversible and can influence the course of treatment. The most advantageous for evaluation of the distance between the floor of a carietic defect and pulp chamber was the study in full colour option.

When a carietic lesion encompassing in clinical examination a large portion of dental crown was detected, there was evaluated the relationship of the floor of such a defect and root furcation on the radiogram. Such piece of information is fundamental in qualification of a tooth for prosthetic treatment, on the condition that no pathologies are found in periapical region. It is also possible to detect an unsymptomatic internal resorption on radiograms, which is not always evident in clinical examination in the form of the so-called pink spot. In own material the resorption was best visualized in densitometric measurements. Also in cases of traumatic lesions it is essential to evaluate radiologically dental crowns in search of fracture lines and their relationship to pulp horns. Pseudo-three-dimensional reformatting of a digital radiogram proved very useful in visualization of traumatic dental crowns injuries.

Before taking up an endodontic treatment dental crowns are analyzed on X-rays. It is vital to assess the angles of root canals as well as to determine the presence of possible calcifications in pulp chambers and root canals, which could be an obstacle in the course of treatment.

In effective dental treatment 90% of success is a correct diagnosis. The clinical examination itself does not give the full insight in dental lesions. Moreover, many pathologies are asymptomatic and only accidentally detected on X-ray images. Thus beginning of a dental treatment without initial radiological examination can be treated as a mistake. Not only the diagnosis but also the long, often multi-stage, treatment requires further radiological controls as well as follow-up examinations months or years after the end of treatment. The application of digital radiography with image enhancement tools instead of conventional radiograms enables reduction in dose of harmful ionizing radiation, creates the possibility of image enhancement, change of gray-scale as well as densitometric meas-

urements. All these functions augment the effectiveness of dental radiological diagnostics based on digital radiography systems, on the condition that their use is optimized.

CONCLUSIONS

1. There was discussed the usefulness of digital radiography in diagnostics of dental crown lesions.

2. There were presented optimum software tools in diagnostics of primary and secondary caries, internal resorption, evaluation of relationship between carietic defect floor and pulp chamber or root furcation as well as in traumatic changes in dental crowns.

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EXPLANATION TO FIGURES

Fig. 1. Primary caries in negative option of digital radiography

Fig. 2. The use of densitometric measurements in differentiation between secondary caries under a filling and a radiolucent dental filling – evident decrease of the densitometric line in the region of secondary carietic lesion

Fig. 3. Slight lowering of the densitometric line on the level of a radiolucent filling

Fig. 4. The option of tomosynthesis allows differentiation of cervical caries and cervical burn-out defects that are triangular in shape

Fig. 5. The use of colour option in evaluation of deep caries

Fig. 6. Fracture line of crown of upper incisor is well visible due to application of pseudo-three-dimensional image

SUMMARY

Digital X-ray imaging systems are an alternative to conventional intraoral radiograms. In the paper there are discussed the possibilities of application of different digital radiography tools as well as density measurements in optimization of diagnostics of pathological lesions of teeth crowns. There were analyzed 1,491 digital intraoral radiograms obtained in 985 patients in the Digora Soredex digital radiography system. On all taken X-ray pictures there were evaluated the crowns of teeth in cases of primary and secondary caries, dental fillings, internal resorption, traumatic lesions of incisors as well as the relationships between deep carietic lesions and pulp horns as well as root furcation. An attempt was made to assess the possibilities of differentiation of cervical caries and cervical burn-out. In the paper there were presented the optimal options of digital radiography software in diagnostics of the discussed pathological lesions.

Optymalizacja warunków wizualizacji koron zębów w radiografii cyfrowej

Cyfrowe zdjęcia rentgenowskie są alternatywą dla konwencjonalnych radiogramów. W pracy omówiono możliwości zastosowania różnych opcji obrazowania w radiografii cyfrowej oraz pomiarów gęstości w optymalizacji diagnostyki zmian patologicznych koron zębów. Przeanalizowano 1491 zdjęć zębowych wewnątrzustnych, wykonanych u 985 osób w systemie radiografii cyfrowej Digora Soredex. Na wszystkich wykonanych zdjęciach oceniano: korony zębów pod kątem obecności próchnicy pierwotnej i wtórnej, wypełnień, resorpcji wewnętrznej, zmian pourazowych w zębach przednich, stosunku dna głębokich ubytków próchnicowych do rogów miazgi oraz do rozwidlenia korzeni. Ponadto próbowano również ocenić możliwości różnicowania próchnicy z niecieniującym wypełnieniem lub podkładem, a także odróżniania zmian próchnicowych w okolicy przyszyjkowej z przejaśnieniami przyszyjkowymi. Wskazano optymalne funkcje oprogramowania, przydatne w diagnostyce poszczególnych omawianych zmian patologicznych.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6