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New means of visualisation of dental caries

Nowe metody wizualizacji próchnicy zębów

Pathological changes in hard tissues of teeth can be detected on a radiograph only in the areas where demineralization of tissues is so advanced that the carietic lesion can be differentiated from normal enamel, dentin and cement.

The radiographs of choice for examination of hard structures of teeth and periodontal tissues are intraoral radiograms. In conventional examinations the receptors of the image are usually films. Imperfection of methods of radiological diagnostics makes the scientists and constructors look for new technologies.

The development in radiology resolves itself into modification of already known techniques, introduction of new techniques of diagnostic visualization and intensification of interpretation of results of examinations (13, 14). Intraoral radiograms became the most often performed radiological examination in men. It is due to rapid development of dentistry and greater demand of the society for this kind of medical services (11). As the intraoral radiograms are so often taken and the need of their use constantly increases, the ways of taking more radiograms using minimum amounts of X–radiation are looked for. The possibilities of improving dental films as well as the means of augmenting their sensitivity are practically over. It induced seeking for new technologies and machines. The result of these investigations was digital radiography (1–4).

Digital radiography uses the same projection techniques as conventional radiography, but the images are recorded by means of an electronic sensor and showed on the screen.

Presently there are used five basic systems of digital radiography: 1) RadioVisioGraphia (RVG) Trophy Radiologie (France), 2) Visualix–Gendex Dental Systems (Italy), 3) Sens–A–Ray – Regam Medical System AB (Sweden), 4) Flash Dent – Villa Sistemi Medicali srl (Italy), 5) DIGORA– Soredex (Finland).

The use of radiovisiography for visualisation of hard tissues of teeth is a great development in the field of dental imaging. This system eliminates the use of a film in dental radiology. The detector of radiation in the case of RVG is an electronic sensor. RVG uses a Charge Coupled Device (CCD) as the receptor of the image. The X–rays come to the scintillator where photons of light originate proportionally to photons of X–radiation. The optic fibers conduct the light from the scintillating screen to the CCD which converts the photons of light into an electrical charge and the electrical charge is converted into a shade of gray. Then the charge in the form of a read out is enhanced and sent to the main processor. This gives an image in a visual scale of gray. The RVG image is shown on the screen immediately after exposition. A considerably lower dose of radiation is required for an RVG image to be taken than in the case of an E speed dental film (5, 7, 9, 10). The contrast of an image can be locally improved by the change of the level of gray. A single pixel in the RVG image can accept every value of gray between 0 and 255 which gives 256 shades of gray. However, human eye can only differentiate from 30 to 40 shades at one time.

Visualization of pathological changes can be more clear using colours – the colours are fitted to the shades of gray by means of computer. The aim of using color images is double: first of all it is a greater differentiation of structures of hard tissues as actually human eye more easily differentiates colours than shadow of gray. On the other hand this function enables communication with patients who prefer the image in colour as more clear (Fig. 1). The use of colour for visualization of obtained images makes the examining person change his way of thinking and interpretation of pathological lesions. Many do not accept colour images as they destroy their usual mental schemes adapted to interpretation of radiograms in a scale of gray (12).

The Digora system is different from RVG mainly in the fact that the roentgen lamp does not have to be connected with the registration plate, which enables the use of every source of X–radiation in order to obtain image on the registration plate. The read out of the plate is direct. Digora also has 256 shades of gray. The registration plate as the image receptor can be used hundreds of times and it is read out by the laser Digora scanner. The image on the registration plate can be obtained in the exposition time of 0.01 sec. at 70 kV and 8 mA. The use of colour in the Digora system is slightly different from that in the RVG. There exists the possibility of showing the areas of the same density by using green colour to visualise the lesions.This colour can enhance some structures or areas of pathological lesions by means of so–called tomosynthesis (Fig. 2).

Another very important function which can be revolutionary for possibilities of interpretation of a radiological image is the function of density measurements. Maybe traditional observations based on morphology and perception of the examiner can be replaced by interpretation based on numbers. This direction of development of diagnostics is the future of dental radiology and leads to the use of artificial intelligence for diagnostic means. The measurements of density used for measurements of a gray scale are made more precisely than it can be detected by a human eye. The so–called "density" of an image means its brightness. Various shades of gray have values of density from 0 to 255. The density measurements can be done in different ways: as statistic information, as density distribution (histogram) and as density profile. Digora measures value of density of pixels within the marked area and shows the values as numbers as well as in the graphical form. Digora measures also density on a marked line and shows the results in the form of a chart (Fig. 3).

MATERIAL AND METHODS

As radiodensitometric examination of teeth in digital radiography has not been worked out yet and so far there have been no contributions concerning this subject, an attempt was made to determine density profiles of tissues of teeth *in vitro*. So far there have been no schemes which could be used in examinations and that is why the aim of the study was to work out such schemes and models of density profiles of physiological teeth structures and pathological lesions. The examinations were carried out *in vitro*. Two systems: radiovisiography and Digora were used for the study. The teeth used in the studies were 50 teeth extracted due to orthodontic reasons and 50 carietic teeth. The radiograms of the studied teeth were taken in four positions: 1. antero–posterior 2. postero–anterior 3. right lateral 4. left lateral in order to visualise as precisely as possible all surfaces of the tooth. By this method the radiograms of both orthodontic and carietic teeth were taken.

All radiograms of teeth *in vitro* positioned in four different ways were analyzed in six options: 1. RVG black and white negative 2. RVG black and white positive 3. RVG colour negative 4. RVG colour positive 5. Digora full color 6. Digora single colour.

EXPERIMENTAL

In order to determine mean value of density of hard tissues of teeth mean density of enamel, dentin, cement, pulp chamber and root canals were studied. The measurements were started with examination of enamel density by means of radiodensitometry of enamel in five points of the crown, that is 1mm from the enamel–cement junction in two directions, in the medium of the crown length and on both sides of the occlusal surface. These measurements were repeated on radiograms in all four positions and then the mean value was calculated. In the same way the cement, dentin, root canals and pulp chambers were examined. Mean values in all studied teeth were shown in the form of a diagram. It was proved that mean density of enamel was 164 points. Dentin density was far lower than enamel density and equalled 127 points. Mean density of cement was 108 points. Next, density of pulp chambers was measured. Here the results differed from 140 to 80 points with the mean value being 96. The measurements of root canal varied from 114 to 47 with the mean value equal to 79 points.

The results of taken measurements were presented in the form of a chart (Fig. 4) and showed considerable differences of tissue density in different teeth. However, it should be underlined that differences in density distribution concern different teeth, the distribution of density between enamel, dentin and cement is proportional in an individual tooth.

It was observed that if the enamel had high radiodensity, the values for both cement and dentin were also higher in comparison with the teeth of lower enamel density. Also density measurements of pulp chamber and root canals were comparatively higher than those in other teeth. The differences between radiodensitometric values of enamel, dentin, cement, pulp chamber and root canal were quite uniform and were about 50 points between enamel and dentin, 30 points between dentin and cement and 20 points between pulp chamber and root canal. In five cases the difference between density values of dentin, cement, pulp chamber and root canal was small, but the difference between measurements of enamel and dentin was high and reached 50 points.

The research and observations made induce continuation of the research work in order to determine density values of physiological and pathological structures of teeth. In the studied material there were carietic teeth with different extent of carietic lesions. In order to find radiodensitometric difference between healthy tissue and carietic lesion the density of carietic area was measured and compared with density of healthy tissues in its neighborhood. If the difference of results is over 20 points, it can be assumed that in the examined area there can be caries. Radiodensitometric chart (Fig. 5) presents changes of density from healthy to carietic tissues.

In order to determine differences between a carietic lesion and prepared cavity other measurements were performed in which radiodensity of prepared carietic cavities, as well as artificial cavities in healthy teeth, was studied. The studies proved that decrease in density in artificial lesions is sudden and equals more than 30 points. It was shown that radiodensitometric measurements can change contemporary methods of dental diagnostics by exchanging subjective viewing of dental radiograms for objective evaluation on the basis of digital radiography.

Caries of adjacent surfaces should be diagnosed by non–invasive means, as examination by means of an explorer can lead to traumatic lesions of enamel. On the other hand, various research works have proved that carietic lesions can be present in teeth dentin without a visual breaking of enamel surface. That is why clinical examination of surfaces can be insufficient for detection of caries on adjacent surfaces of teeth.

On the basis of analysis of over 5,000 digital radiograms an initial selection of studied archive material was made. 1,118 radiograms of carietic teeth were chosen and analyzed in 6 options. It was proved that radiological examination increased sensitivity of adjacent surfaces caries in comparison with only visual control, without increasing false positive results. Beginning caries on adjacent surfaces within enamel. On the densitogram there can be seen a slight fall of densitometric curve.

Beginning caries on adjacent surfaces exceeding enamel, entering dentin is best seen on RVG negative image and in the option of full colour in Digora, which is confirmed by the densitogram.

Medium caries in enamel and dentin, but not exceeding half of the width of dentin is identified as sudden fall of densitometric curve in the area of carietic lesion.

Deep caries is visible in all options. On the densitogram the change of density is higher than 80 points.

Secondary caries under restoration is difficult to visualise on radiograms but it is best seen after using the option of tomosynthesis. On the densitogram there is a distinct sudden fall of densitometric curve, which confirms the diagnosis (Fig. 6).

CONCLUSIONS

1. On the basis of carried out research and obtained results it was proved that it was possible to precisely determine the presence of pathological changes in hard teeth structures. The research confirmed that pathological changes in hard tissues of teeth can be correlated with characteristic radiodensitometric values.

2. Analysing radiodensitometric measurements some regularities in density distribution of teeth were discovered.

3. On the basis of the authoress' own material the model schemes of radiodensitograms characteristic of different physiological and pathological conditions of teeth were worked out. These models can be helpful for dentists in diagnosing different teeth pathologies.

4. The possibility of using digital radiography for precise diagnosis of extent and type of pathological changes of hard teeth structures was proved.

5. The benefits of using Digora Soredex for analysis of various types of caries were shown.

6. It was proved that the newest system of digital radiography Digora can be used for analysis of radiograms taken in other systems, for example RVG.

REFERENCES

1. Benz C.: Einsatz der Radiovisiographie in der Endodontic. Endodontic, 3, 197, 1992.
2. Benz C. et al.: Untersuchung des nenen Radiovisiographic–System. Dtsch. Zahnarztl Z., 45, 728, 1990.
3. Chen S–K. et al.: Detector response and exposure control of the RadioVisioGraphy System (RVG 32000 ZHR). 76, 1, 104, 1993.
4. Da Silva A.N., De Andrade D.C.: Radiovisiografia, Stoma. Impl., 4, 5, 1994.
5. Duret F. et al.: The RadioVisioGraphy (RVG) where reality surpasses radiological fiction, a hope that is becoming reality. J. Dent. Admin., 5, 138, 1988.
6. Fujita M. et al.: Digital image processing of periapical radiographs. Oral Surg. Oral Med. Oral Pathol. 65, 490, 1988.
7. Forman A.G.: Basic technical properties of a system for direct acquisition of digital intraoral radiographs. Oral Surg. Oral Med. Oral Pathol. 75, 4, 506, 1993.
8. Horner K. et al.: Radiovisiography: an initial evaluation. Br. Dent. J. 168, 244, 1990.
9. Mouyen F.: The possibilities of the latest RVG 32000. Dentomaxillofac. Radiol. 191, 11, 83, 1991.
10. Różyło T.K.: Zastosowanie radiografii cyfrowej do wizualizacji tkanek twardych zębów. Stomatologia Współcz., 3, 5, 379, 1996.
11. Różyło T.K.: Radiodensytometryczne badania zębów *in vitro*. Stomatologia Współcz., 3, 6, 471, 1996.
12. Różyło T.K.: Zastosowanie radiowizjografii do diagnostyki próchnicy zębów. Mag. Stomat., 12, 48, 1996.
13. Wenzel A., Fejerskov O.: Accuracy of laboratory diagnostic performance of detecting caries in clinically sound occlusal surfaces of third molars. Caries Res., 25, 16, 1991.
14. Wenzel A. et al.: Depth of occlusal caries assessed clinically, by conventional film radiographs, and by digitized, processed radiographs. Caries Res., 24, 327, 1990.

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STRESZCZENIE

Rozwój stomatologii zmusza do szukania nowych rozwiązań technologicznych, zarówno leczenia, jak i diagnostyki. Dotychczasowa niedoskonałość metod diagnostyki radiologicznej zmusiła do poszukiwania nowych metod wizualizacji, co zaowocowało wynalezieniem radiografii cyfrowej. Radiografia cyfrowa używa tych samych technik projekcji, co radiografia konwencjonalna, ale obrazy są

zapisywane za pomocą elektronicznego czujnika i wyświetlane na monitorze. Otrzymane obrazy można oglądać w kolorach. Dodatkową bardzo ważną funkcją, która może zrewolucjonizować możliwości interpretacyjne obrazu rentgenowskiego, jest funkcja pomiaru gęstości tkanek. Umożliwia on bardzo precyzyjne wykazanie różnic wysycenia i może być przedstawiony w postaci wykresu. Ta funkcja pozwala na dokładne określenie zmian patologicznych struktur zębów w miejscach, gdzie ani badania kliniczne, ani konwencjonalne radiologiczne badanie nie może być wykorzystane. Radiografia cyfrowa jest szczególnie przydatna do oceny próchnicy wtórnej jak też próchnicy na powierzchniach stycznych zębów.

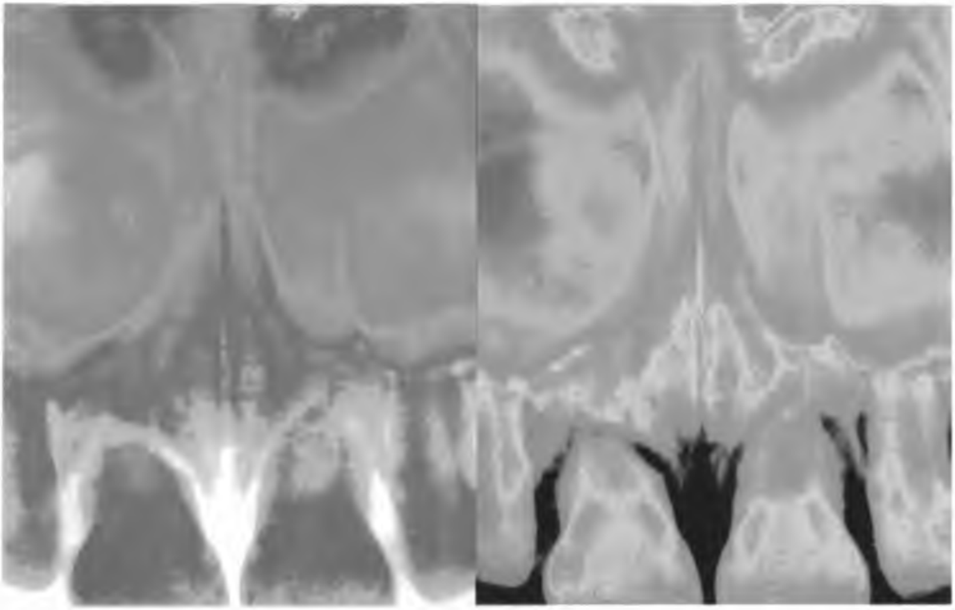

Fig. 1. RVG radiogram - colour positive and colour negative

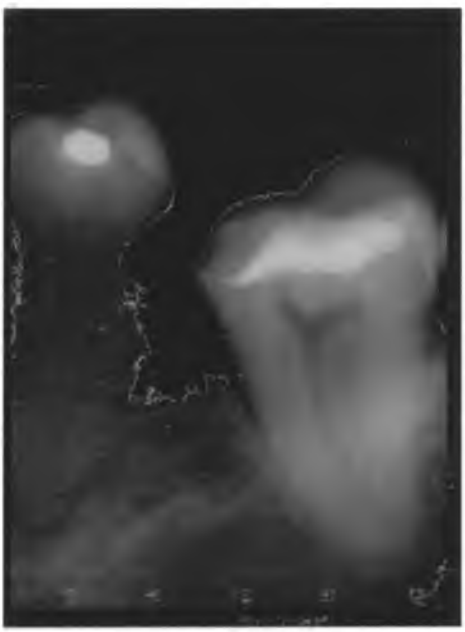

Fig. 2. Visualisation of pathological lesions of tooth hard tissues using tomosynthesis

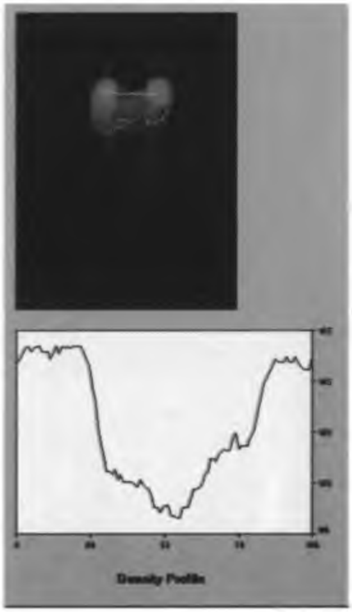

Fig. 3. Density measurements on the marked line

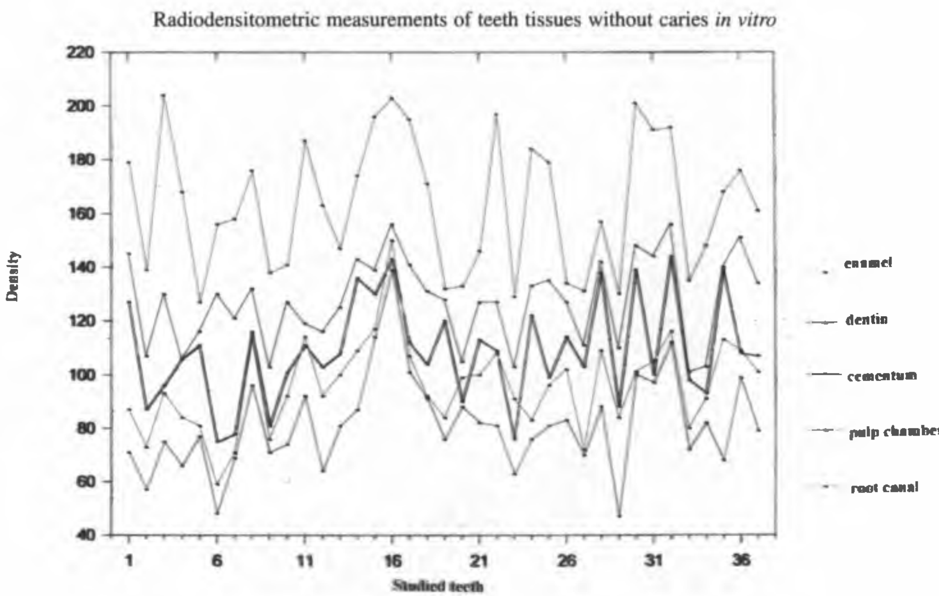

Fig. 4. Chart showing density profile of tooth tissues

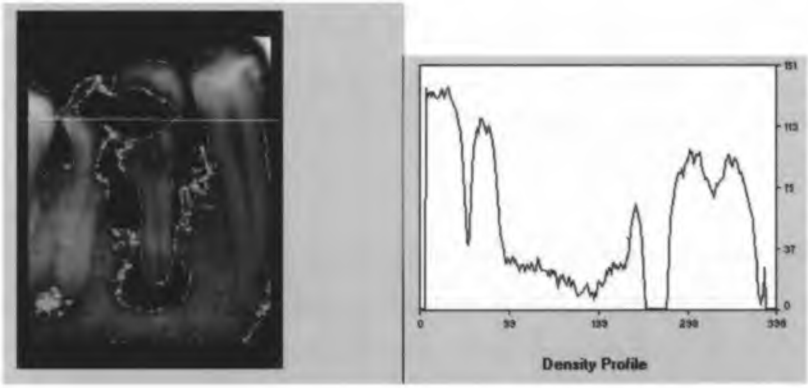

Fig. 5. Visualisation of caries by means of a radiodensitogram

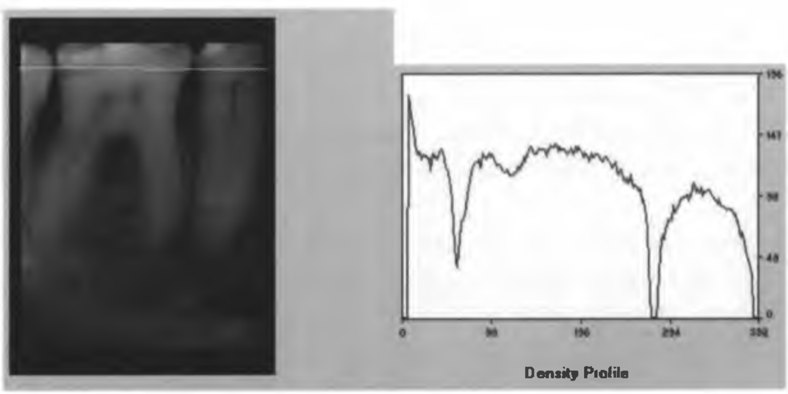

Fig. 6. Radiodensitogram of secondary caries under restoration