Evaluation of Periodontal Pockets using Different Biomaterials
A preliminary study

OANA-ALEXANDRA VELEA[1#], COSMIN SINESCU[1*#], CORNELIU ZEICU[1#], PAUL CORNEL FREIMAN[2#], PUIU IULIAN VELEA[3#], DOINA ONISEI[1#], VIRGIL-FLORIN DUMA[#4,5]

[1]"Victor Babes" University of Medicine and Pharmacy of Timisoara, Faculty of Dental Medicine, Imaging Group, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[2]"Vasile Goldis" Western University of Arad, 94 Revolutiei Blv., 310025, Arad, Romania

[3]"Bega"Clinic II Pediatrics, 1-3 Evlia Celebi Str., 300226, Timisoara, Romania

[4]3OM Group Optomechatronics, Aurel Vlaicu University of Arad, 77 Revolutiei Av., 310130, Arad, Romania

[5]School of Physics, West University of Timisoara, 4 VasileParvan Av., 300223, Timisoara, Romania

A multitude of systems are used for the detection of the periodontal pockets and the alveolisis, including systems with periodontal or thermal probes, densitometric analyses, radiographic periodontal evaluation, and the Cone Beam Computed Tomography (CBCT). The advantages and drawbacks of 7 of these methods are compared first and CBCT is chosen for the investigation proposed. CBCT has become of interest in the periodontology evaluation of the bone density and of the periodontal defects associated with these pathologies. However, the CBCT exam is based mainly on the evaluation of hard tissues; periodontal pockets cannot be visualized using this method on a 3D reconstruction. To overcome this drawback, the present study is testing several biocompatible adjuvant substances, to serve as contrast substances. The periodontal pockets of 5 selected patients have been investigated with the 3D CBCT exam, after having inserted different types of biocompatible materials. Specifically, gold and silver nanoparticles, ZnO, ZrO_2, and $BaSO_4$ were used as contrast substances. 2D images and 3D reconstructions of the periodontal pockets were obtained with each of the above substances. The study has proved so far that ZrO_2 and $BaSO_4$ are the only contrast substances that can be used successfully due to their radio opacity. However, it is difficult to cover using them the entire depth of the periodontal pocket.

Keywords: Cone Beam Computed Tomography (CBCT), periodontal pockets, alveolisis, periodontal probing, contrast substances, gold and silver nanoparticles, zirconia.

The health of the gingival tissues that support the teeth may be affected by the periodontal disease (PD) [1].In order to detect the periodontal pockets produced between the gums and the tooth and the alveolisis, classical methods are largely used nowadays. Periodontal probing is the best method to diagnose and to gather information concerning the status of periodontal health[2]. A synthesis of the most used equipment utilized for this purpose is made in table 1.

Radioimagery studies based on the latter method, CBCT, although not very numerous in the literature, have demonstrated the advantages of computerized tomography in dental medicine [14, 15]. Also, the use of scanning devices with relatively low radiation doses facilitates the examination of anatomic structures in a multiplane image [16, 17].

The CBCT method is thus preferred and used in dental medicine for a multitude of purposes: (i) to locate the inferior alveolar nerve; (ii) to analyse the included molars; (iii) to perform the endodontic evaluation; (iv) to visualize the odontogene lesions of temporo-mandibular joint structures; (v) to analyse the existant space for implants at a scale of 1:1; (vi) to evaluate the paranazal sinuses and the location of maxillary sinuses; (vii) to evaluate different injuries; (viii) to visualize and to evaluate temporary anchor devices; (ix) to make 3D models by using CAD/CAM devices; (x) to visualize the bone structures and its associated pathology.

Lately the extension of CBCT use have also become of interest in the periodontology evaluation of the bone density and of the periodontal defects associated with these pathologies. However, as the CBCT exam is based mainly on the evaluation of hard tissues (bones), periodontal pockets cannot be usually visualized using this method on a 3D reconstruction; only the socket process is evident.To overcome this drawback, the present study is testing several biocompatible adjuvant substances, to serve as contrast substances. It will be demonstrated that using some of these substances, the periodontal pockets are becoming evident on the 2D images and on the related 3D reconstruction. The difficulty is to optimize the substances and the procedures. The issue that apear will also be pointed out for further study.

The aim of the present work is to investigate the possibility to determine and to evaluate the periodontal pockets by using the CBCT technique.This is done after inserting beforehand different biocompatible materials as contrast substances – which is the main novelty of this study.The comparison of the images of the periodontal pockets obtained will be based on the radioopacity of each material used.

Experimental part

Five patients with ages between 40 and 70 years, selected from the private dental practice were investigated in the Dental Radiology Center DENTAVIS, Timisoara,

* *email: minosinescu@yahoo.com; Tel: 0722280132*

 # These authors equally contributed to the work

Equipment	Features of the apparatus	Features of the method	Characteristics of the probe	Advantages and drawbacks
The Community Periodontal Index of Treatment Needs [1, 3]	The recommended mass of the probe is 20-25 g. The periodontal probe has to be inserted gently in the gingival ditch in maximum 6 points of the tooth surface. The evaluation is made according to 6 codes.		The probe is equipped with a blunt ending or a small ball with 0.5 mm diameter and a coloured band of 3.5 mm to 5.5 mm.	The system of periodontal probing offers a constant probing force; the data obtained is transmitted to a computer (PC); a precise management of the inflamation registered is performed.
Florida Probing System [1, 4]	It has a periodontal probe, a pedal, a digital display, an interface and a PC - with an automatic transfer of the data to the PC.	The system registers the relative changes of the clinical level of the attachement; the occlusal surface of the teeth is the fix point of referrence.	The probe has an active end with a 0.4 mm diameter. It is easier to register the cemento-enamel junction using the 0.125 mm edge of the probe.	The accuracy in detecting the cemento-enamel junction is increased. The practitioner thus has the possibility to measure at the same time the the probing depth and the attachment level.
Toronto Automat [1, 5]	Similar to the Florida probe, it uses the occlusal and the incisal surface to measure clinically the attachment levels.	By using a mercury sensor, the discrepancies that limitate the angularity up to 30° can be controlled.	The gingival sulcus is probed with a 0.5 mm nichel-titanium thread extended under air pressure.	The apparatus requires a stable position of the patient's head; it also measures with difficulty the attachment that faces the molars 2 and 3.
The PerioTemp [1, 6]	Thermal probes are sensitive instruments that achieve the measurement of early changes of the gingival inflamation.	The method allows for the calculation of the temperature differences between the probed zone and the sublingual temperature. These differences are compared with the normal ones for each tooth. The periodontal spaces with increased temperature are signaled with a diode. The sublingual temperature of the affected zones is increased with regard to the healthy zones, while there is an antero-posterior natural thermal gradient - the posterior areas are warmer than the anterior ones at the level of the dental arch.		Sublingual temperature is connected to the attachment loss. Bacteria like *Prevotella Intermedia, Peptostreptococcus micros, Porphyromonas gingivalis, Tannerella forsythia* and *Actinobacillus actinomycetemcomitans* can be found in high enough concentrations at the sites with increased temperatures [6].
Radiographic periodontal evaluation [1, 7, 8]	It is the most important instrument for paraclinical diagnose, based on panoramic, retroalveolar, bite-wings and substractive radiographies (with the digital format gaining ground for all of them). The changes in the density and the volume of the bone are detected as light coloured zones (increase of the bone volume and density) or dark coloured zones (bone loss).		Substractive radiographies are based on the use of a positioning device during the exposure - with a dedicated software for substractive digital imaging.	Substractive radiography achieves a qualitative and quantitative evaluation. Minor bone changes are shown, as the technique removes the stable anatomic structures from the image. Quantitative changes are detected, compared with basic images, by using an algorithm with different shades of gray (PC-generated).
CADIA - system of densitometric analyses of the image assisted by a computer [1, 9]	The system consists of a video camera, an image processor, and a PC.	The system measures the light transmitted through an X-ray exam. The camera signals are transformed into images with different shades of gray. They are stored for the image processing.		This objective method evaluates quantitatively the modifications of the bone density. It has a higher sensitivity, accuracy, and reproductibility with regard to the substractive analysis.
The Soredex-cranex tridimensional (3D) imagistic system - containing panoramic programs, cephalometrical and 3D Cone Beam Computed Tomography (CBCT) [10-13]	The system has stability and accuracy of the patient's positioning - with a rigid positioning system in 5 points, an easy adjustment, and 3 lasers for a correct positioning.	CBCT is a radiographic 3D method. It has a superior quality of the image, a sensitive CMOS sensorial technology, and an improved flow of 3D images.	The 3D images can be obtained both with the patient sitting or standing; they are processed directly in the DICOM format – a software specialized for diagnosis.	The computerized tomography has significant advantages in dental medicine [10]. It presents a high accuracy imaging of the dentition and of the visualized adherent structures, at a scale of 1:1, in a conical radius [11, 12]. The diagnosis is accurate, rapid, and performed with a very low radiation dose [13].

Table 1
SYSTEMS AND METHODS USED FOR ERIODONTAL PROBING. AN OVERVIEW

Romania. The working protocol for this study was approved by the Ethics Committee of the „Victor Babes"University of Medicine and Pharmacy Timisoara. All experiments were conducted according to Romanian and European Union regulations.

The patients were diagnosed with periodontal disease (PD) in different stages of evolution, having periodontal pockets with different depths; the most severe one had a depth of 6 mm. The periodontal pockets were inserted with different biocompatible materials:

(1)gold and silver nanoparticles provided by the NANOCARE Company (Dental nanotechnology, Katowice, Poland).

(2) ZnO substance for dental use (powder produced by Lucstar Prod. S.R.L, Bucharest, Romania).

(3) Zirconia (ZrO_2) solution (powder produced by Al_2O_3/ZrO_2 VITA In Ceram Classic).

(4) $BaSO_4$ solution (S.C. Meduman S.A., Maramures, Romania).

The gold and silver nanoparticles were acquired under the form of solutions, in 1.5 mL ampoules. They have several advantages: (i) bacteriostatic and antifungic properties; (ii) they are neutral from a chemical point of view;(iii) their components do not react with the farmaceutical substances usually used in dental treatments, and this preserves their properties; (iv) they do not disactivate in the presence of light; (v)additionally, the gold particles positively influence the adhesion of composite materials to dentine and they do not decolorate the restaurations [18,19].These nanoparticles have been mainly used previously in prosthodontics and endodontics in order to protect the dental surface against bacterial adherence, in the case of microfissures. In endodontics they are being used for the final irrigation of the endodontic space, preventing the bacterial recolonization and the loss of physical and chemical properties [19]. Because of these advantageous characteristics, their use in this application may also be of interest.

The other three biocompatible materials, i.e. the ZnO,ZrO_2 and $BaSO_4$ solutions were prepared mingling the ZnO and ZrO_2 powders with water, having a creamy consistency. In order to increase their density and opacity, in two of the cases medicinal vaseline was used as a transporting medium.

The different solutions were introduced in the periodontal pockets with 2 mL syringes, for the administration of the hypodermic shots, with short, thin and flexible needles. In the case of the vaseline used as a transporter, the solutions obtained were inserted with 5 mL syringes with plastic, curved applicator with a large lumen.

The evidence and the evaluation of periodontal pockets was made by a CBCT examination using a Soredex-cranex 3D system instaled at the DENTAVIS Timisoara.The CMOS Flat Panel of the system is used with two values of the field of view: the lower one is combined with a higher resolution (which depends on the exposure time of the scanning), while the higher one is related to a lower resolution. The system utilizes a X-rays generator with a 0.5 mm focus point, a voltage of 57-90 kV, and an anodic power of 4-16 mA.

The 3D reconstructions were made by employing the OnDemand 3D App software for dental images. This software utilizes CT and MR DICOM files (the standard format for medical files and images [13])in order to make possible the 3D visualization of Multi-Plane Reformator of the panoramic sectional, sagital and of temporo-mandibular joint images. The advanced tools analyse 2D and 3D images;the 3D module, with various reconstruction functions is advantageous for its qualitative segmentary visualization and analytical functions of the DICOM image.

Results and discussions

The patients included in the study were subject to the insertion, in identical conditions, of the biocompatible materials used as contrast substances in the periodontal pockets at increased depths. Later, the periodontal pockets were evaluated with the help of the 3D CBCT system, exploring, obtaining the images in 2D, and reconstructing them in 3D.

Periodontal pockets in which gold and silver nanoparticles were inserted did not present changes in aspect on the 3D reconstruction. The inserted solutions could be very difficulty to identify radioimagistically in both of the two cases because of their too low density, much too close to that of the saliva (fig. 1).

a b

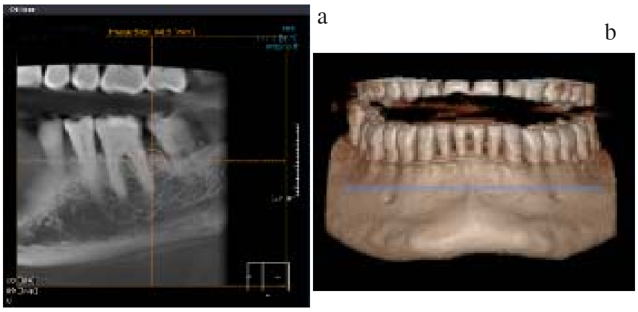


Fig. 1. (a) Radiographic aspect and (b) 3D reconstruction after the insertion of the gold nanoparticles in the periodontal pockets (similar results are obtained with silver nanoparticles)

For the ZrO_2 and ZnO solutions (prepared from Zn and Zr powder and water), changes were noticed in the 3D reconstruction only in the case of the ZrO_2 and $BaSO_4$ solutions, which are obviously of an increased radioopacity (fig. 2). Therefore, the ZrO_2 and $BaSO_4$ solutions may serve successfully as contrast substances in order to make the periodontal pockets more evident. In the case of the ZrO_2 solution, the only shortcoming is represented by the fact that the insertion is made with difficulty because of the hypodermic syringes with thin, flexible needles, the solution reflows from the periodontal pocket (fig. 2c).

In order to surpass this shortcoming we also mingled the ZrO_2 and ZnO powders with medicinal vaseline, as a transporter, in order to increase the density of the solution.The insertion was performed this time with special 5mL syringes equipped with plastic applicators with a larger lumen. However, these substances could not have been put into evidence on the 3D reconstruction in these conditions.

$BaSO_4$(largely used as a contrast substance in general medicine for the radiological visualization of the colon – irigography [20])was used in a dose of 1 gr (4 packages of 250mg) disolved in about 2 liters of warm water.It was introduced in the periodontal pockets of a patient, comparatively, mingled with warm water at the level of 3.6 dental unit and mingled with vaseline at 4.7 tooth level. This was visible on the 3D reconstructions due to the increased radioopacity only in the case of mingling the powder with warm water (3.6 dental unit, fig. 3). The only inconvenience in this case was represented by the fact that although the substance remained in the periodontal pocket, it was positioned only in its coronary area, round the interdental contact point, and not in the depth of the pocket as well (fig. 3c, d).

This study has opened further research directions in the study and diagnosis of the PD. To the best of our knowledge, this approach, with contrast substances inserted in the periodontal pockets has not been made before.The obvious limitations of the method have to be addressed further on. From what we have determined, the future discussions and studies on this subject must start from several key questions:

(i)How should the substance which would serve as a contrast substance be prepared optimally, what quantities of powder and liquid (or other alternate transporter) must be used in order to become radioopac enough and to remain in the periodontal pocket?

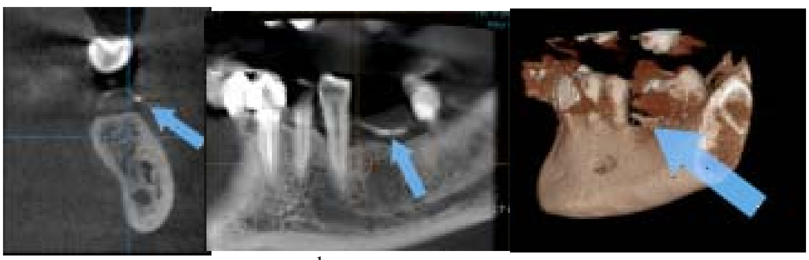
(ii)Why does the Zr and $BaSO_4$ powder mingled with a liquid may be noticed on the 3D reconstruction, and why it is not made obvious in the vaseline mingle? May vaseline diminish the radioopac properties of Zr and $BaSO_4$?

(iii)May there be necessary a greater quantity of Zr or $BaSO_4$ powders - these being the only radioopac and visible media on a 3D reconstruction prepared with water?

(iv)How should the insertion of the $BaSO_4$ powder be optimized further on to assure the filling of the entire periodontal pockets?

Another limitation of this study is represented by the investigation conditions of the patients; as we have used so far a radiology center without a dental unit with aspiration, the saliva makes the insertion and the remaining of the substance in the pocket difficult, even in conditions of isolations with cotton rolls.

Radiographic exploration of PD even by using the CBCT exam and 3D reconstruction does not confirm a diagnose in an incipient stage.Demineralization and bone lesions are being detectable only when 30% of the bone substance is lost.It only aims at a more precise evaluation of the periodontal pockets evident together with the alveolisis phenomenon in PD. While it has not been used as a usual method of diagnosis and establishing a prognostic or an exact treatment place, the investigation of bone and soft tissue lesions by CBCT method is presumably going to gain more ground. The advantages of this investigation are



a b c

Fig. 2. (a), (b) Radiographyc aspects and (c) lateral view of the 3D reconstruction after inserting the ZrO_2 sol.ution in the periodontal pockets

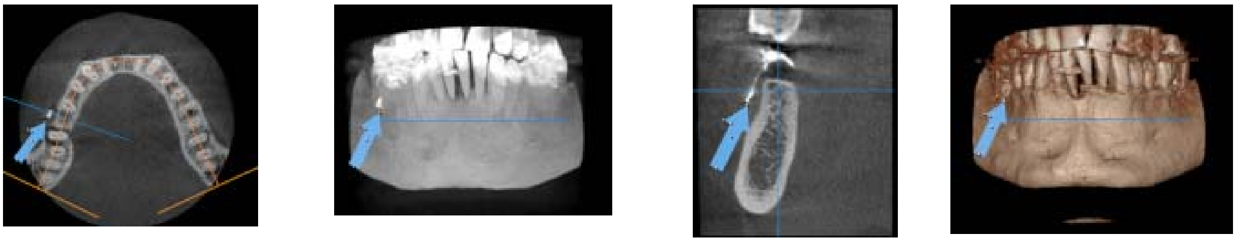


Fig. 3. (a), (b) Radiographic aspect, (c) radiographic detail, and (d) 3D reconstruction after inserting the $BaSO_4$ solution in the periodontal pockets

represented by the speed of execution, by passing from a 2D radiographic investigation to a 3D one, with a low dose of radiations, and by saving the information in a computerised program with multiple possibilities of dynamic evaluation of the different anatomical structures involved.

Conclusions

The CBCT exam presents numerous advantages in investigating the alveolar bone structures, as compared to the classical 2D radiographies. However, the periodontal pockets cannot be seen on classical CBCT 3D reconstruction; only the alveolisis is being visible.Using contrast substances to eliminate this drawback has been the main idea of this study. Thus, the use of ZrO_2 and $BaSO_4$ solutions showed that the mix of Zr powder with water is radioopac and visible on a 3D reconstruction. Therefore it can make the periodontal pockets visible as well. Several shortcomings were met, were in part corrected, and have to be further addressed: (i) the low density of the basic substances of gold and silver nanoparticles make their detection difficult while using a CBCT exam; (ii) the thin and flexible needles produce the reflow of the substances mixed with water from the periodontal pocket; (iii) ZnO, ZrO_2 or $BaSO_4$ powders mixed with medicinal vaseline lead to obtaining some substances with an increased density which, injected with larger needles, can be kept in the periodontal pocket; however they are not evident enough on a 3D reconstruction.

Future work comprises addressing these questions in detail to improve the method and to make use of the superior 3D imaging capabilities of the CBCT used with contrast substances in the investigation of the periodontal pockets.

Acknowledgements: This work was supported by a Partnership grant of the Romanian Authority for Scientific Research, CNDI–UEFISCDI project PN-II-PT-PCCA-2011-3.2-1682 (http://3om-group-optomechatronics.ro/). C. Sinescu also acknowledges the support of the TE 101/2010 CNDI–UEFISCDI grant.

References

1.CARRANZA, F.A., Carranza's Clinical Periodontology, 10th Edition, Edited by Cochrane DL, Giannobile WV, Kenney EB, Novak MJ. St. Louis, Elsevier 2007.

2.ARMITAGE, G.C.,Clinical-evaluation of periodontal-diseases, Periodontol. 2000, 7, 1995,p. 39.

3.QUIRYNEN, M., CALLENS, A., VAN STEENBERGHE, D., et al.,Clinical-evaluation of a constant force electronic probe,J.Periodontol., 64, 1993, p. 35.

4. RAMS, T.E., LISTGARTEN, M.A., SLOTS, J.,Utility of 5 major putative periodontal pathogens and selected clinical parameters to predict periodontal breakdown in patients on maintenance care,J.Clin.Periodontol., 23, 1996, p. 346.

5.McCULLOCH, C.A., BIREK, P.,Automated probe: futuristic technology for diagnosis of periodontal disease,Univ. Toronto Dent. J., 4, 1991, p. 6.

6.HAFAJEE, A.D., SOCRANSKY, S.S., GOODSON, J.M.,Subgingival temperature (II). Relation to future periodontal attachment loss,J. Clin. Periodontol., 19, 1992, p. 409.

7. HAUSMANN, E.,Radiographic and digital imaging in periodontal practice,J.Periodontol., 71, 2000, p. 497.

8.NUMMIKOSKI, P.V., STEFFENSEN, B., HAMILTON,K., et al.,Clinical validation of a new substraction radiography technique for periodontal bone loss detection,J.Periodontol, 71, 2000, p. 598.

9.BRÄGGER, U., PASQUALI, L., RYLANDER, H., et al.,Computer-assisted densitometric image analysis (CADIA) for the assessment of alveolar bone density changes in furcations,J. Clin. Periodontol., 15, 1988, p. 27.

10.VIJAY, G., VIJAY, R., J. Indian Acad. Oral Med. Radiol., 25, 2013, p. 24.

11.ABE, H., MACMAHON, H., ENGELMANN,R., et al.,Computer-aided diagnosis in chest radiology: results of large-scale observer tests performed at the 1996-2001 RSNA Scientific Assemblies,RadioGraphics, 23, 2003, p. 255.

12.GOMES-FILHO, I.S., SARMENTO, V.A., DE CASTRO,M.S., Radiographic features of periodontal bone defects: evaluation of digitized images,DentomaxillofacRadiol., 36, 2007, p. 256.

13.www.soredex.com/products/cranex-3d/features.aspx

14.MISCH, K.A., YI, E.S., SARMENT, D.P.,Accuracy of cone beam computed tomography for periodontal defect measurements,J. of Periodontology, 77, 2006, p. 1261.

15.DEFARIA VASCONCELOS, K., EVANGELISTA, K.M., RODRIGUES, C.D., ESTRELA, C., DESOUSA, T.O., SILVA,M.A.,Detection of periodontal bone loss using cone beam CT and intraoral radiography, DentomaxillofacRadiol., 41, 2012, p. 64.

16.MAH, J.K., DANFORTH, R.A., BUMANN, A., HATCHER,D.,Radiation absorbed in maxillofacial imaging with a new dental computed tomography device,Oral Surg Oral Med Oral Pathol Oral RadiolEndod, 96, 2003, p. 508.

17.ALHADIDI, A., CEVIDANES, L.M.S., MOL, A., et al., Comparison of two methods for quantitative assessment of mandibular asymmetry using cone beam computed tomography image volumes,Dentomaxillofacial Radiology 40, 2011, p. 351.

18.AI, J., BIAZAR, E., JATARPOUR, M., MOUTAZERI, M., et al.,Nanotoxicology and nanoparticle safety in biomedical designs,International J. of Nanomedicine 6, 2011, p. 117.

19. *** www.dentalnt.com

20. SCHOEPF, U.J., BECKER, C.R., OBUCHOWSKI,N.A., Multi-slice computed tomography as a screening tool for colon cancer, lung cancer and coronary artery disease, European radiology, 11, 2001, p. 1975.

Manuscript received: 20.06.2014

Several shortcomings were met, were in part corrected, and have to be further addressed: (i) the low density of the basic substances of gold and silver nanoparticles make their detection difficultwhileusing a CBCT exam; (ii) the thin and flexible needles produce the reflow of the substances mixed with water from the periodontal pocket; (iii) ZnO, ZrO_2 or $BaSO_4$ powders mixed with medicinal vaseline lead to obtaining some substances with an increased density which, injected with larger needles, can be kept in the periodontal pocket; however they are not evident enough on a 3D reconstruction.Future work comprises addressing these questions in detail to improve the method and to make use of the superior 3D imaging capabilities of the CBCT used with contrast substances in theinvestigation of the periodontal pockets.

Acknowledgements: This work was supported by a Partnership grant of the Romanian Authority for Scientific Research, CNDI–UEFISCDI project PN-II-PT-PCCA-2011-3.2-1682 (http://3om-group-optomechatronics.ro/). C. Sinescu also acknowledges the support of the TE 101/2010 CNDI–UEFISCDI grant

.References

1.CARRANZA, F.A., Carranza's Clinical Periodontology, 10th Edition, Edited by Cochrane DL, Giannobile WV, Kenney EB, Novak MJ. St. Louis, Elsevier 2007.
2.ARMITAGE, G.C.,Clinical-evaluation of periodontal-diseases,Periodontol. 2000, 7, 1995,p. 39.
3.QUIRYNEN, M., CALLENS, A., VAN STEENBERGHE, D., et al.,Clinical-evaluation of a constant force electronic probe,J.Periodontol., 64, 1993, p. 35.
4. RAMS, T.E., LISTGARTEN, M.A., SLOTS, J.,Utility of 5 major putative periodontal pathogens and selected clinical parameters to predict periodontal breakdown in patients on maintenance care,J.Clin.Periodontol., 23, 1996, p. 346.
5.McCULLOCH, C.A., BIREK, P.,Automated probe: futuristic technology for diagnosis of periodontal disease,Univ. Toronto Dent. J., 4, 1991, p. 6.
6.HAFAJEE, A.D., SOCRANSKY, S.S., GOODSON, J.M.,Subgingival temperature (II). Relation to future periodontal attachment loss,J. Clin. Periodontol., 19, 1992, p. 409.
7. HAUSMANN, E.,Radiographic and digital imaging in periodontal practice,J.Periodontol., 71, 2000, p. 497.
8.NUMMIKOSKI, P.V., STEFFENSEN, B., HAMILTON,K., et al.,Clinical validation of a new substraction radiography technique for periodontal bone loss detection,J.Periodontol, 71, 2000, p. 598.
9.BRÄGGER, U., PASQUALI, L., RYLANDER, H., et al.,Computer-assisted densitometric image analysis (CADIA) for the assessment of alveolar bone density changes in furcations,J. Clin. Periodontol., 15, 1988, p. 27.
10.VIJAY, G., VIJAY, R., J. Indian Acad. Oral Med. Radiol., 25, 2013, p. 24.
11.ABE, H., MACMAHON, H., ENGELMANN,R., et al.,Computer-aided diagnosis in chest radiology: results of large-scale observer tests performed at the 1996-2001 RSNA Scientific Assemblies, RadioGraphics, 23, 2003, p. 255.
12.GOMES-FILHO, I.S., SARMENTO, V.A., DE CASTRO,M.S., Radiographic features of periodontal bone defects: evaluation of digitized images,DentomaxillofacRadiol., 36, 2007, p. 256.
13.www.soredex.com/products/cranex-3d/features.aspx
14.MISCH, K.A., YI, E.S., SARMENT, D.P.,Accuracy of cone beam computed tomography for periodontal defect measurements,J. of Periodontology, 77, 2006, p. 1261.
15.DEFARIA VASCONCELOS, K., EVANGELISTA, K.M., RODRIGUES, C.D., ESTRELA, C., DESOUSA, T.O., SILVA,M.A.,Detection of periodontal bone loss using cone beam CT and intraoral radiography,DentomaxillofacRadiol., 41, 2012, p. 64.
16.MAH, J.K., DANFORTH, R.A., BUMANN, A., HATCHER,D.,Radiation absorbed in maxillofacial imaging with a new dental computed tomography device,Oral Surg Oral Med Oral Pathol Oral RadiolEndod, 96, 2003, p. 508.
17.ALHADIDI, A., CEVIDANES, L.M.S., MOL, A., et al., Comparison of two methods for quantitative assessment of mandibular asymmetry using cone beam computed tomography image volumes,Dentomaxillofacial Radiology 40, 2011, p. 351.
18.AI, J., BIAZAR, E., JATARPOUR, M., MOUTAZERI, M., et al.,Nanotoxicology and nanoparticle safety in biomedical designs,International J. of Nanomedicine 6, 2011, p. 117.
19. www.dentalnt.com
20. SCHOEPF, U.J., BECKER, C.R., OBUCHOWSKI,N.A., Multi-slice computed tomography as a screening tool for colon cancer, lung cancer and coronary artery disease, European radiology, 11, 2001, p. 1975.

Manuscript received: 20.06.2014