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SEDENTEXCT

Safety and Efficacy of a New and Emerging Dental X-ray Modality

Newsletter

Inside this issue:

Project partners

University of Manchester (UK), National and Kapodistrian University of Athens(Greece), "Iuliu Hategianu" University of Cluj-Napoca (Romania), Leeds Test Objects Ltd. (UK), Katholieke Universiteit Leuven (Belgium), Malmő University (Sweden), Vilnius University (Lithuania).

More about SEDENTEXCT at: www.sedentexct.eu

EURATOM

The Seventh Framework Programme of the European Atomic Energy Community (Euratom) for nuclear research and training activities (2007 to 2011)

Editorial: Dose Optimisation for CBCT

A striking feature of dosimetry studies for CBCT equipment is the range of doses delivered to patients for, ostensibly, the same clinical examinations. This was highlighted in the SEDENTEXCT Provisional Guidelines on CBCT produced in May of 2009.

Recommendations for optimising doses to patients in CBCT have been promulgated based on consensus (notably the EADMFR Basic Principles for Use of Dental Cone Beam CT), empirical and experience-based knowledge and on limited research evidence. These emphasise using the smallest volumes, choosing the appropriate exposure and kV settings, appropriate resolution choice and consideration of using a reduced number of "basis" images. Such guidance is, however, so general that it is hard for the average dentist to decide what to do for an individual patient. Even a medical physicist may have problems here, because a judgement on selecting the exposure parameters needs a sound knowledge of how this choice will affect physical and psychophysical measures of image quality and, in turn, how these influence diagnostic value of images.

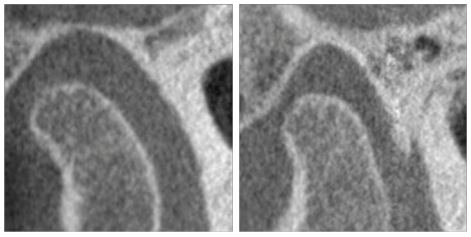
The use of "Reference doses" and "Diagnostic Reference Levels" (DRLs) are an important aspect of optimisation. DRLs are patient dose levels for medical diagnostic exposure that can be used as investigation levels as part of the optimisation process. The International Commission on Radiological Protection (ICRP) first introduced the term diagnostic reference level in 1996. The requirement for DRLs was included within the European Medical Exposures Directive 97/43 Euratom of 1997 and the EC produced further guidance on the setting of DRLs in 1999. National agencies are, however, still at the early stages of accumulating the quantity of data needed to produce DRLs. Where DRLs are based on doses delivered in clinical practice, there is a risk that such doses are not fully optimised because the equipment users lack the evidence to lower exposure parameters without affecting image quality.

It is in relating optimisation strategies to clinical image quality that considerable work remains to be performed. One important step in this process is to have accepted standard methods of assessing image quality that are appropriate for the specific needs of CBCT. Until recently, assessment of CBCT image quality depended on using test tools and phantoms designed for other imaging systems (e.g. CT). A few manufacturers produce their own test objects, but this good practice is far from universal. One of the SEDENTEXCT Work packages aims to develop a phantom that can satisfy the need for a "universal" CBCT quality control test tool that could be applied by physicists and clinicians to all equipment that they encounter.

Progress in this Optimisation Work Package has been excellent, not least due to the contribution of one of the SEDENTEXCT partners, Leeds Test Objects (http://www.leedstestobjects.com/) a globally recognised manufacturer of medical X-ray test objects. The work package scientists, led by Prof. Kostas Tsiklakis (*University of Athens*) are now at a stage where they will be looking to collaborate with CBCT manufacturers to obtain feedback on its use prior to its commercial release. I look forward to seeing this tangible output of SEDENTEXCT taking its place as the clinical standard for establishing the correct operating performance of CBCT equipment in Europe and beyond.

Keith Horner

SEDENTEXCT Project Co-ordinator



Optimisation in action. CBCT images of temporomandibular joints. The one on the right was taken using half the radiation dose of that one the left by using a half rotation.

SEDENTEXCT Consortium meet in Malmö

SEDENTEXCT scientists have planned project meetings arranged every six months. While we use regular electronic methods of communication, ranging from email and intranet through to Skype and videoconferencing to sort out everyday issues, we feel that it is important to "get together" regularly to review progress and identify any areas requiring action. At the 24 month point in the project, this meeting is also a formal "Periodic Review", required by the EC as part of its Seventh Framework Programme.

Stortorget, Malmö

On January 7-8th, we met in Malmö, hosted by Prof. Christina Lindh at the excellent conference accommodation offered by the Radisson Blu Hotel. On the 7th January, there were a number of Work package "Workshops", designed to push forward the specific agendas of the project component elements. This included an intensive Work package 6 "brainstorm" looking at training packages for CBCT that will be developed in the next six months.

The formal project meeting was held on Friday 8th January, where we welcomed our new Project Officer, Roberto Passalacqua. Roberto recently took over this role, following the retirement of Henning von Maravic in summer of 2009. See p.6 of the Newsletter for his profile.

We look forward to our next Project meeting in Cluj, Romania on 2nd July 2010.

Project meeting in Malmö. From the left: Keith Horner (Co-ordinator), Roberto Passalacqua (EC Project Officer). Hugh Devlin (WP6), Christina Lindh (WP5), Reinhilde Jacobs (WP4), Ria Bogaerts (WP2), Kostas Tsiklakis (WP3).

SEDENTEXCT at two years

A regular part of our Newsletter is an update on the activities of the scientists in the SEDENTEXCT project. At times, the reader may feel that we are being "opaque" in our descriptions of work; this is necessary because some of the work is not yet ready for placing in the public domain, particularly where this involves potential intellectual property issues. Nonetheless, we hope that a useful idea of our work can be gained.

Work package 1 (http://www.sedentexct.eu/content/work-package-1-justification-and-guideline-development)

This WP addresses guideline development through an "evidence-based" approach.

Following the publication of the "Provisional Guidelines on CBCT" in May 2009, the WP work went into a planned "quiet" phase, consisting only of regular reviews of publications appearing in the literature concerning CBCT. Nonetheless, scientists took this opportunity to review the process of critical review, data extraction and guideline development that had been used in the preparation of these guidelines. The result has been to re-design the proformas used for sifting and classifying publications, with the aim of achieving more efficiency and better allocation of studies for appraisal to match reviewers' expertise.

At the time of writing, WP1 is beginning a new phase of active appraisal, a little in advance of the planned timeline, so that we have ample time for developing our "Definitive" guideline document.

Work package 2 (http://www.sedentexct.eu/content/work-package-2-dosimetry)

This Work package works to conduct dosimetry studies on CBCT (patient and staff doses) and to develop effective methods for dosimetry modelling.

For all tasks in the dosimetry work package, experimental work was started or continued during the second year of the project. A large amount of CBCT devices were involved in the measurements of adult and paediatric effective dose, 2D and 3D dose distribution, patient skin dose, and scatter dose. All the dosimetric data is currently under evaluation. Furthermore, a Monte Carlo simulation framework has been set up, and simulations are currently being performed and validated. During the course of 2010, all measurements will be finished up, analyzed and reported.

Work package 3 (http://www.sedentexct.eu/content/work-package-3-optimisation)

This Work package involves the SME partner, Leeds Test Objects Ltd, and there are important IP issues that prevent detail entering the public domain. As such, this is a limited report.

The last six months have involved testing of a second prototype phantom. A lot of effort, however, has gone into developing the software that accompanies the phantom and is used for analysis of results. We are closer to the point at which we can involve manufacturers of CBCT equipment to obtain their input and feedback.

Work package 4 (http://www.sedentexct.eu/content/work-package-4-diagnostic-accuracy)

This Work package deals with "diagnostic accuracy" in clinical applications.

WP4 consists of three tasks, that can be summarised as 1) in vitro accuracy studies (human bone), 2) *in vitro* accuracy studies (animal bone) and 3) clinical diagnostic accuracy studies. In 2009, a great deal of work has been spent in creating and processing the large datasets of scans of several skulls using 12 different CBCT devices. The team of Cluj visited the Oral Imaging Center in Leuven for extending the dataset of the animal study. Cluj is in the process of analysing these sets in extensive observer studies. Gradually approaching the final reporting stage of the *in vitro* studies, increasing attention was paid to the recruitment and data collection for the clinical diagnostic accuracy studies. This recruitment is ongoing and Cluj as well as Leuven have expended considerable effort to reach the targeted numbers. They reached the share for the implant and 3rd molar impaction studies. The recruitment of patients with impacted canines and with sinus grafts is still ongoing and needs careful follow up.

Work package 5 (http://www.sedentexct.eu/content/work-package-5-cost-effectiveness)

This Work package is exploring the

difficult and challenging area of economic evaluation of Cone Beam CT and collaborating with team members with international expertise in health economics.

Work has continued on the cost calculations related to the exemplar clinical situation: the impacted maxillary canine. These calculations have now been completed and will be reported in a future journal publication.

The other half of the work deals with clinical efficacy. Observers are now viewing images of the patients from the study in order to identify the "added value" of CBCT by comparing "old" and "new" imaging approached. This is demanding research, requiring several observers in time-consuming efforts, but we believe that the results will be worthwhile. In particular, the methodology emphasises *diagnostic thinking efficacy* rather than diagnostic accuracy alone.

Work package 6 (http://www.sedentexct.eu/content/work-package-6-training-and-valorisation)

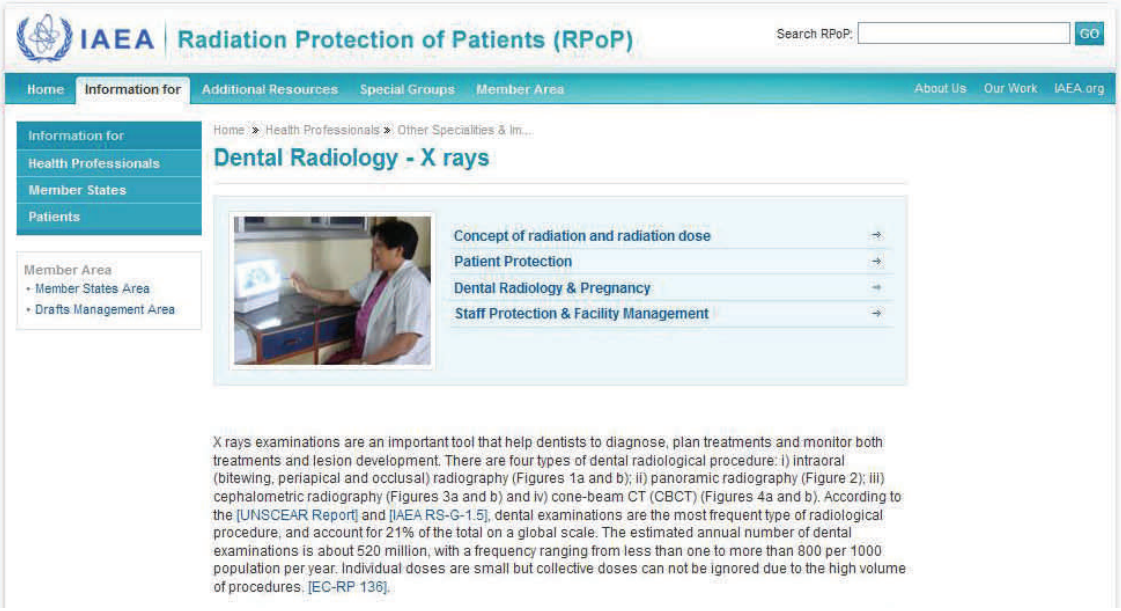
This element of the project deals with "Training and valorisation".

During the last six months, our Web Developer has been working on the structure of the website, particularly as regards the provision of information and training materials. The main approach to training will be using the Wiki for transmission of factual material that anyone can "dip into". A more formal training will be available using a combination of the Wiki, Powerpoint lectures with voiceover, with interactive elements tailored to specific subjects. It is hoped that considerable progress will be achieved in the next six months.

At the moment, the Wiki is only open to project members, but we will review the situation and consider inviting external individuals to contribute in due course, as part of a developing online community.

One recent addition is Information for Patients. We are aware that the website may be visited by the public seeking information and this is a first step to address this need.

IAEA website updated to include CBCT information



The "Radiation Protection of Patients" website pages of the International Atomic Energy Agency (IAEA) are a valuable source of information for the public, states and health professionals. The IAEA's International Action Plan on the Radiation Protection of Patients (2002) includes an action on using mechanisms for widely disseminating information related to the protection of the patient; the website

pages are a means of achieving this.

In 2009, the IAEA decided to update its website in relation to Dental Radiology and invited four people to spend an intensive few days at their Vienna headquarters to make progress on this task. The team was Ritva Bly (*Finland; STUK Säteilyturvakeskus*), Andrew Gulson (*UK; Health Protection Agency*), Leos Novak (*Czech Republic; Státní Ústav Radiační Ochrany*) and Keith Horner (*EADMFR and SEDENTEXCT project*). These were chaired and facilitated in the work by Dr. Madan Rehani (*Radiation Protection Unit, IAEA*).

The new web pages are now updated to include information about CBCT, including recommendations about optimisation and justification, with a link through to the SEDENTEXCT Provisional Guidelines on CBCT on the project website. This is a valuable example of a mutually beneficial collaboration which will help to bring the work of SEDENTEXCT to a wider audience than Europe alone.

The IAEA "Radiation Protection of Patients" Dental Radiology website pages can be found at:

http://rpop.iaea.org/RPOP/RPoP/Content/InformationFor/HealthProfessionals/6_OtherClinicalSpecialities/Dental/index.htm

Alternatively, start at the homepage at: http://rpop.iaea.org/RPOP/RPoP/Content/index.htm

and take some time to explore the whole site and its information on the range of medical uses of radiation.

Profile: young scientists in SEDENTEXCT

Sophia Gavala

My name is Sophia Gavala. I graduated from Faculty of Dentistry in Plovdiv in 1998. I worked in a private dental clinic and in 2000 I was involved in a quality assurance project of the oral radiographic devices of the private dental clinics in Athens with the cooperation of the Department of Oral Radiology and Diagnosis of the Dental School in Athens, Athens Dental Society and Greek Atomic Energy Commission. In 2002 I started my postgraduate studies and I accomplished a Master's thesis on dosimetry of panoramic and cephalometric radiography and I obtained the MSc degree in Oral Radiology and Diagnosis in 2006. I also work in the Forensic Dentistry team in the Department of Oral Radiology and Diagnosis and as a dentist in my private dental clinic. Since 2008 I have been a PhD student in Oral Radiology, Dental School of University of Athens, Greece.

My involvement in work package 2 of the SEDENTEXCT project has given me the opportunity to collaborate with European researchers, to expand my knowledge in dosimetry at a higher level, as well as to exchange scientific experience with colleagues from Universities of different European countries. It is a great honour for me to participate in this project, to collaborate with great researchers and I look forward in completion of this project, since it will be a useful tool for the CBCT users and I hope in a continuing European cooperation, especially for the young scientists, who gain great experience, knowledge and basis for future career.

DENTAL SCHOOL
ATHENS UNIVERSITY

Guozhi Zhang

Guozhi Zhang received the B.Eng. degree in Bioinformatics from Huazhong University of Science and Technology, China, in 2008. He was previously with the Brit-

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ton Chance Center for Biomedical Photonics, at Wuhan National Laboratory of Optoelectronics, China, and is now pursuing the Ph.D. degree in medical sciences with the Department of Radiology, University Hospitals Leuven, Belgium. His research is about 3D and 4D modeling of computational phantoms for radiation dosimetry and imaging in cone-beam x-ray computed tomography, especially for the head and neck region. Studying as well with the team of the Oral Imaging Center at KULeuven and being the only non-European person involved in the SedentexCT project, he is assisting in part of the image processing and software coding work.

Profile: our new Project Officer

Roberto Passalacqua

Roberto PASSALACQUA is a nuclear engineer with a PhD in "severe accident management guidelines".

He started his carrier in the field of radiological protection, designing the radiation monitoring system of PWR reactors for the Italian nuclear industry ANSALDO-NIRA. Afterwards, at the National Committee for Nuclear Research (ENEA), he contributed to the promotion of "nuclear safety research" through the definition, coordination and monitoring of design/R&D contracts with industry and universities.

After the Italian nuclear moratorium in 1988, because of the downsizing of the Italian nuclear sector, he worked, as a consultant, in several countries with the highest nuclear standards (as Canada and Switzerland). In particular, he worked at IPSN-Cadarache in France for the development and validation of nuclear safety computer codes (e.g. ESCADRE and ASTEC).

Under contract with the FUS (Fusion) Department of ENEA, he also contributed to the estimation of the source term of the NET-ITER fusion reactor (radioactive aerosol behaviour and transport for reference accident sequences as in-vessel and ex-vessel loss of coolant).

Roberto has a large experience in the field of safety assessments: he contributed to the development of a "Safety Monitor" for the fast-breeder Monju reactor in Japan and, since early 2002, working for the European Commission, he has implemented several projects for the modernization of nuclear reactors of the new Member States Lithuania and Bulgaria.

He also had a rewarding team-leading experience improving the Bulgarian participation to the 6th research Framework Programme (within the FP6 SARNET Network of Excellence) and contributing to the preparation of communication products / events (e.g. "JRC Information Days in Bulgaria".

Since August 2009 Roberto is a scientific/ technical project officer at DG RTD where he contributes to the technical orientation, co-ordination, development and implementation of relevant EURATOM policies in the unit "Nuclear Fission and Radiation Protection" (RTD J2). This includes managing the entire project cycle, including the financial management of a set of projects in his area of competence.

Roberto believes in the importance of education and social progress: he has participated for more than a decade to the activities of the Italian AGESCI boy-scouts organization. He is self-motivated, disciplined, problem-solving, with a high team-spirit and feeling of commitment and always aiming at improving the sharing of knowledge.

He is still an active skier and in general a very good TV/armchair sportsman. He has a strong passion for the history of arts and, in summer, he enjoys his old motorbike.

Selected abstracts

Paediatric organ and effective doses in dental cone beam computed tomography
C. Theodorakou, K. Horner, K. Howard, A. Walker
Presented at the World Congress of Medical Physics, Munich, 7-12 September 2009.

Cone beam computed tomography (CBCT) is an x-ray emerging technology with wide applications in the dental and maxillofacial disciplines. Dental CBCT has been associated with higher radiation risk to the patients compared to conventional dental x-ray imaging.

Several studies have investigated the radiation doses involved in dental CBCT for adults but none has looked into paediatric doses. This study estimates the organ and effective doses to two paediatric tissue-equivalent phantoms using thermoluminescent dosimeters for three dental CBCT units and six imaging protocols.

The doses to the thyroid, salivary glands and brain ranged from 0.068mSv to 1.131mSv, 0.708mSv to 2.009mSv and 0.031mSv to 1.584mSv respectively. The skin and red bone marrow have received much lower doses than the other three organs. The effective doses ranged from 0.022 mSv to 0.081 mSv. The highest effective dose was calculated for the NewTom VG using the dental protocol and the lowest was observed for the Next Generation i-CAT using the 6cm maxilla protocol. The effective doses calculated in this study were much higher than these of panoramic x-ray imaging but lower than conventional CT.

Radiation protection considerations for dental cone beam computed tomography equipment
A. Walker
Presented at the UK Institute of Physics and Engineering in Medicine meeting: "Developments in Dental Radiology", Manchester, 16 December 2009.

Dental cone beam CT (CBCT) units are beginning to be installed in hospital Maxillo Facial departments, community dental clinics and orthodontic practices. These units are associated with higher dose than current dental X-ray equipment used within such practices with the implication that a greater level of protection will be required for both the operator and staff in adjacent areas. The footprint of many dental CBCT models is very similar to that of traditional panoral X-ray equipment leading to concern that they may be installed in locations that provide inadequate radiation protection. The HPA working group on dental CBCT has considered the radiation protection aspects of room design and will be issuing some interim guidance shortly that will be of help to RPAs in providing advice on the installation of dental CBCT. This guidance will be outlined in this presentation including the following aspects: Scatter radiation dose rates, workload and distance assumptions for structural protection calculations, sample room shielding calculations, operator protection, safety and warning features. Calculations indicate that for a high kV, large field of view unit with a workload of 50 scans per week and only 0.5 m from the nearest wall, 2.3 mm lead is needed to comply with the 0.3 mSv p.a. dose constraint for a high occupancy area. This is probably a worst case scenario and many installations may be satisfactorily shielded with lower lead equivalences; possibly as low as Code 2 (0.9 mm) lead for the lower dose, low kV units.

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http://cordis.europa.eu/fp7/euratom/ .

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