DIMITRA: Dentomaxillofacial paediatric imaging: an investigation towards low dose radiation induced risks

DIMITRA consortium

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AIM:

This project focuses on the uncertainties associated with radiation-induced health risks at low doses in paediatric dentistry. It is a multidisciplinary effort to approach the involved risks through four different yet interrelated tasks: radiobiological characterization, dosimetric quantification, epidemiological surveying and image quality & dose optimization.

TASK 1: Characterising the risks

I. **Orofacial (stem) cells** will be exposed to **low doses of X-irradiation** (0, 5, 10, 20, 50 and 100 mGy). **DNA damage and repair** kinetics (via γH2AX visualisation) will be analysed along with the **profile of secreted proteins** (e.g. cytokines). The obtained results will enable specification of potential early radiation–induced biomarkers. Dental Pulp Stem Cells (DPSC), Stem cells from Human Exfoliated Deciduous teeth (SHED), Stem Cells from Apical Papilla (SCAP) and Gingival Fibroblasts (FIGI) will be used.

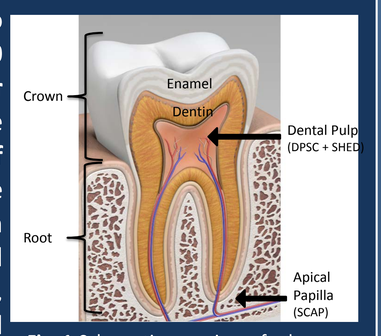

Fig. 1 Schematic overview of a human tooth. (TurboSquid; http://www.turbosquid.com/3d-models/3d-tooth-cross-section/676790)

II. **Oral epithelial cells** will be collected in paediatric patients undergoing CBCT. γH2AX foci will be used as a biomarker to detect **DNA damage and repair** in the low dose range in these exfoliated oral epithelial cells. In addition, DBS repair protein MRE11 will also be used as a marker of radiation-induced DNA damage.

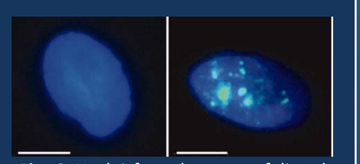

Fig. 2 Nuclei from human exfoliated oral epithelial cells. (Left) Nucleus stained with DAPI. (Right) Normal nucleus after γ-irradiation showing several γH2AX foci (FITC, green signal), which are indicative for DSB in the DNA. (González *et al.,* Int J Radiat Biol, 2010, 86, 752-759)

III. **Saliva**, the 'mirror of the body', has its own proteome containing numerous biomarkers that are also found in plasma. These proteins can reflect the physiologic state of the body. A **pilot study** will be set up to analyse **oxidative stress** by measuring the expression of **8-oxo-7,8-dihydro-2'-deoxyguanosine** in saliva collected from paediatric patients before and after CBCT examinations.

TASK 2: Quantifying the doses

I. An EGSnrc-built Monte Carlo (MC) framework has been developed and customized for dosimetric applications in dental CBCT (fig.1). The dosimetric platform has been configured to model the spectral, geometric and rotational characteristics of a Promax 3D Max (Planmeca, Helsinki, FIN) and a Vgi-evo (Newtom, Verona, IT) scanner. The validity of MC dose calculations has been tested against experimental dose measurements in water for every clinical protocol (max. 7%).

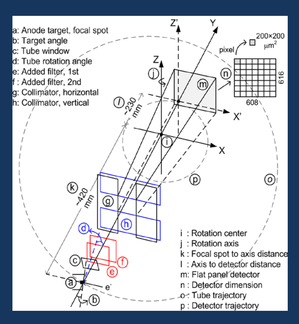

Fig. 1 graphical representation of the MCframework

II. Patient specific voxel models (age and gender equivalent) will be designed for each child paricipating in the study. Voxel models are based on head and neck CT image datasets, ensuring that all the radiosensitive organs are included in the model (fig.2). Each voxel model consists of 22 segmented organs, i.e. skin, brain, cartilage, connective tissue, air cavities, arteries, esophagus, eyes, eye lenses, fat, mandible, skull, red bone marrow, muscle, extrathoracic region, teeth, tongue, trachea, thyroid, salivary glands, oral mucosa and spinal cord.

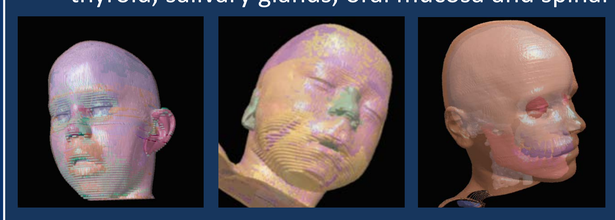

Fig. 2. 5 years old male, 8 years old male and 12 years old female voxel models

III. Each patient-specific voxel model will be loaded to the scanner and protocol - specific MC dose simulator, to enable accurate organ dose calculations. The radiation induced risk in terms of effective dose and LAR (Life Attributable risk) will be estimated for each patient.

TASK 3: Surveying the risks through epidemiology

I. **Retrospective analysis of dose on pediatric population** will analyze a cohort group of patients aged between 0-22 years selected from four different oral radiology centers in Cluj-Napoca. The effective dose for children was retrospectively estimated based on the type of examination, equipment and settings, age and gender of the patients and referred pathologies. The effective dose for CBCT was estimated by using DAP value and conversion coefficients for CBCT calculated in Task 2. The effective dose for 2D radiography was calculated using conversion factor of Helmrot and Alm Carlsson for 60-75kV and Batista equation for voltages >75kV;

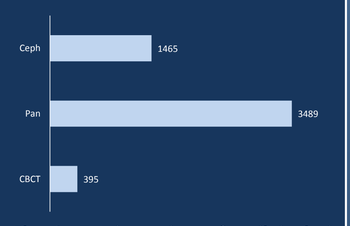

Fig. 1: Total number of radiological examination in children

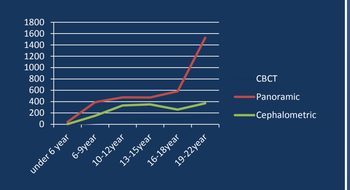

Fig. 2: The frequancy of dental radiological examination by age group

II. **Prospective analysis of dose response for CBCT** examination will analyze the cumulative dose in children group based on their radiological records and a questionnaire that investigates all radiological exposure.

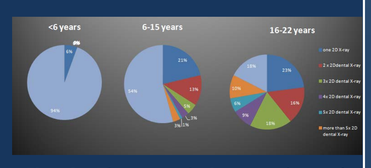

Fig. 3: The cumulative number of dental radiological examination by age group

III. **A Specific cohort of cleft lip and palate** patients will estimate the cumulative dose for group of cleft palate patients compared to dose for children without cleft.

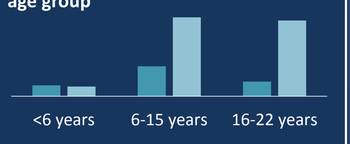

Fig. 4: The frequancy of dental radiological compare to other X-Ray

TASK 4 : Reducing risks through image quality optimization

Quality  **Dose**

I. Identification of common indications for paediatric CBCT and related image quality criteria

CLINICAL INDICATIONS
CLINICAL IMAGE QUALITY CRITERIA

II. Subjective and objective image quality assessments from a range of CBCT protocols.

Paediatric phantoms

SEDENTEXCT phantoms

III. Guidelines regarding optimized protocols related to indications.

Subjective Quality ROC analysis
Objective Quality
RECOMMENDATIONS OF OPTIMIZED PROTOCOLS
Task 2 Doses

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