Measurement of Skin Dose from Dental Cone-Beam CT Scans

Innovation/Impact: The field of dental x-ray imaging has changed dramatically over the past decade because of the introduction of cone-beam CT (CBCT) based systems designed for dental imaging. Since 2001, the number of CBCT dental units and the utilization of the CBCT dental imaging procedures have increased rapidly. There have been increased concerns about dental CBCT radiation dose to patients especially to children. The main target organ in cases of CT-induced radiation injury is the skin. On November 21, 2010, The New York Times raised the concern of radiation dose to children from CBCT for dental imaging: **"Radiation Worries for Children in Dentists' Chairs"**. In the community, questions have been asked about the relative CBCT dose in comparison to intraoral radiography, panoramic radiography and medical diagnostic CT. In response to these concerns and questions, recent guidance documents have been developed or are under development by several international groups including the American Dental Association (ADA) which provides guidelines of the safe use of CBCT in clinical practice. **AAPM also submitted an official letter in December 2011 in responding to a request from the ADA for comments on the draft guidance document.** This highlights the great need for an effective technique to directly measure and monitor patient skin dose during the clinical procedures. However, there currently exist no established techniques to direct measure the skin dose distribution on patients and little published data on measured skin doses. To answer this clinical need, our research is investigating an OSL-based nanoDOT system (Landauer) for direct measurements of patient skin dose from dental CBCT scans of different systems and compared them against measurement results from conventional panoramic and cephalomic dental imaging.

1. A number of radiosensitive tissues of interest were identified for positioning the nanoDOT dosimeters at. A head anthropomorphic phantom was used with nanoDOT dosimeters attached as shown below. To ensure reliable measurement results, three dosimeters were used for each location.

2. Skin dose distribution measured using nanoDOTs. As expected, the results depend on x-ray tube output (kVp and mAs) and also are sensitive to the SFOV: if a dosimeters was entirely or partially included in the radiation field, or was outside the field. In comparing to doses from CBCT systems, doses delivered from the Panoramic and Cephalometric systems are at least lower by an order of magnitude.

Sirona Galileos				
kVp	85		85	
mAs	21		42	
SFOV	15 X 15		15 X 15	
Dose in mGy	Skin Dose	StdDev	Skin Dose	StdDev
Right Lens	0.48	0.04	0.76	0.09
Left Lens	0.67	0.18	1.11	0.32
Right Submandibular	1.93	0.08	3.56	0.12
Left Submandibular	1.93	0.11	3.66	0.17
Right Parotid	2.3	0.08	4.31	0.27
Left Parotid	2.49	0.02	4.62	0.1
Thyroid	0.36	0.01	0.46	0.01
Maximum	2.49		4.62	

Kodak 9500				
kVp	86		120	
mAs	108		108	
SFOV	15 X 9		20 X 18	
Dose in mGy	Skin Dose	StdDev	Skin Dose	StdDev
Right Lens	0.48	0.03	3.84	0.08
Left Lens	0.36	0.01	3.25	0.06
Right Submandibular	3.58	0.03	4.03	0.07
Left Submandibular	2.49	0.34	3.32	0.25
Right Parotid	3.5	0.17	4.15	0.14
Left Parotid	2.25	0.07	2.99	0.14
Thyroid	0.32	0.02	0.45	0.01
Maximum	3.58		4.15	

Planmeca - Panoramic Mode		
kVp	66	
mAs	144	
SFOV	25 X 30	
Dose in mGy	Skin Dose	StdDev
Right Lens	0.05	0
Left Lens	0.04	0
Right Submandibular	0.14	0.02
Left Submandibular	0.14	0.02
Right Parotid	0.23	0.06
Left Parotid	0.26	0.04
Thyroid	0.07	0.01
Maximum	0.26	

iCAT Classic								
kVp	120		120		120		120	
mAs	18.54		18.54		20.27		37.07	
SFOV	16 X 13		23 X 17		16 X 13		23 X 17	
Dose in mGy	Skin Dose	StdDev	Skin Dose	StdDev	Skin Dose	StdDev	Skin Dose	StdDev
Right Lens	1.82	0.02	1.01	0.04	1.16	0.03	1.66	0.02
Left Lens	1.68	0.02	0.83	0.02	1.65	0.16	1.54	0.04
Right Submandibular	1.78	0.23	1.44	0.06	1.37	0.05	2.52	0.08
Left Submandibular	1.81	0.08	1.03	0.05	2.22	0.14	1.94	0.07
Right Parotid	2.08	0.1	1.36	0.1	1.59	0.09	2.46	0.03
Left Parotid	1.77	0.04	0.93	0.05	2.62	0.11	1.64	0.1
Thyroid	0.25	0	0.25	0.01	0.24	0.1	0.39	0.02
Maximum	2.08		1.44		2.62		2.52	

Planmeca - Cephalometric Mode		
kVp	68	
mAs	112.2	
SFOV	30 X 27	
Dose in mGy	Skin Dose	StdDev
Right Lens	0.05	0.01
Left Lens	0.09	0.01
Right Submandibular	0.04	0
Left Submandibular	0.09	0.01
Right Parotid	0.04	0
Left Parotid	0.09	0.01
Thyroid	0.05	0
Maximum	0.09	

3. The peak skin dose was found on Parotid when a CBCT system was used. Sirona and Kodak systems delivered higher doses than other systems. The highest dose from the lens of the eyes was ~4mGy, from the Kodak system. The doses to the eyes from all of the dental imaging systems were significantly lower than the 500mGy threshold dose which may cause cataract development.

Highest dose for each imaging system		
Imaging System	Location	Skin Dose, mGy
Sirona	Left Parotid	4.6
Kodak	Right Parotid	4.2
iCAT	Left Parotid	2.6
Panoramic	Left Parotid	0.3
Cephalometric	Left Lens	0.1

Highest dose at each location		
Location	Imaging System	Skin Dose, mGy
Right Lens	Kodak, 120kVp	3.9
Left Lens	Kodak, 120kVp	3.3
Right Submandibular	Kodak, 120kVp	4
Left Submandibular	Sirona, 42mAs	3.7
Right Parotid	Sirona, 42mAs	4.3
Left Parotid	Sirona, 42mAs	4.6
Thyroid	Sirona, 42mAs	0.5