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Research Article

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CBCT Dose Reduction to Lens of Eye Using Leaded Glasses

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Abstract

Objectives: *The objective of this study was to measure the shielding effect of leaded glasses, tanning glasses with 1/16" Pb shielding and tanning glasses with lead foil in combination with thyroid collar compared with no shielding equipment to the lens of the eye to evaluate the percentage of dose reduction.*

Methods: *A CIRS female phantom head was used to measure the patient radiation dose to the organs of the head and neck from a Morita X800 CBCT using nano Dot optically stimulated luminescent dosimeters (OSL'S) placed at 23 head and neck sites. Leaded glasses, tanning glasses with 1/16" Pb shielding, tanning glasses with lead foil were placed over the phantoms eyes in conjunction with a thyroid collar. No Protective Equipment was used as a control. Radiation was performed using manufacturers predetermined exposure settings. All dosimeters were exposed three times. Radiation dose fractions to various organ sites were determined using reference values from ICRP-89. Organ equivalent doses were based on ICRP-103 tissue weighting factors.*

Results: *The per cent reduction to the lens of the eye for the leaded glasses compared to no Protective Equipment was 49.2%, 44.6% for the tanning glasses with 1/16" Pb shielding and 38.1% for the tanning glasses with lead foil. For all modes of eye wear the highest organ doses were seen in the salivary glands, extrathoracic airway, and the oral mucosa. The use of proper PPE is necessary to protect the eye from possible cataractogenesis.*

Conclusions: *Research on the correlation between cataract formation and ionizing radiation has shown that the dosage and frequency of exposure play a role in damaging the DNA in the lens of the eye. Here we demonstrate that regular leaded glasses and the tanning glasses with 1/16"Pb shielding are about equal in reducing the dose to the lens of the eye. One caviat, the size of the regular lead glasses might interfere with anatomical landmarks while tanning glasses would allow more diagnostic information. Further studies should be performed.*

Background

Radiation induced damage to the lens of the eye can include the loss of clarity resulting in an opacification or clouding several years later after exposure. The impact is highly dependent on the type of radiation, how the exposure to the lens was delivered, the genetic susceptibilities of the individual exposed, and the location of the opacity relative to the visual axis of the individual. The International Commission on Radiation (ICRP has concluded that lens damage can occur at lower doses than previously recommended. It is prudent to reduce the annual lens of eye occupational dose from 150 mSv to an absorbed dose of 50 mSv/yr while the NCRP has reduced the recommended dose to the lens of the eye for the public to 15 mGy/yr [1]. There is a need for additional research to evaluate the overall effects of ionizing radiation to the lens of the eye and to use dose sparing optimization techniques along with epidemiology studies to understand the mechanisms of cataract development.

Over the past 70 years, the ICRP has issued various advisories concerning dose limits to the lens of the eye for radiation workers and the public [1-5]. In fact in 1977, the NCRP classified cataracts as "deterministic effects" and in 2007 as "tissue reactions". More recently in 2012, the International Commission on Radiation Protection (ICRP) recommended a reduction to the eye dose for workers utilizing low dose ionizing radiation to 0.5 Gy It has

been proposed that low-dose ionizing radiation can cause DNA damage to the epithelial cells of the lens of the eye which could lead to cataract formation and visual problems. In dental radiology the chances of ionizing radiation causing cataract formation is slim but with the greater use of CBCT, especially in Orthodontics, where the prime patients are children with labile tissue there is a possibility of causing future vision problems.

In previous papers we reported that the use of leaded glasses reduced the radiation dose to the lens of the eye by 36-62%, but this was for only two specific machines [6,7]. Other machines would give different percentages as no two CBCT machines emit the same amount of radiation at identical machine settings. Recent papers by Hamada and Barnard are updates on the effects of ionizing radiation on the lens of the eye [8,9]. Barnard hypothesized that low level ionizing radiation can cause unusual DNA damage to the epithelial cells of the eye lens when compared to other tissue. This conclusion was derived from animal studies and not human studies. Hamada states that a long held tenet did not change, namely that the lens of the eye is among the most radiosensitive tissues in the body and most radiosensitive ocular tissue. He also questions whether there is a low dose threshold for changing the DNA of the lens epithelial cells to form cataracts and whether cataracts are categorized as tissue reactions warrant further investigation. With the ICRP reducing the annual eye lens equivalent dose to 50 mSv from all protocols we previously investigated and reported on the use of leaded glasses and thyroid shield on reducing the dose to the lens of the eye during CBCT scans for Orthodontics. One caviat was that the size of the regular leaded glasses interfered with the capability to use anatomical landmarks for Orthodontic tracings. Here we are attempting a novel approach using smaller tanning glasses with lead foil and with 1/16" Pb shielding to determine their protective qualities.

Materials and Methods

A CIRS female phantom head, CIRS model 702, (Computerized Reference Imaging System, (CIRS), Norfolk, Va.) was used to measure the patient radiation dose to the organs of the head and neck from a Morita X800 CBCT (Morita, Japan) using nanoDot optically stimulated luminescent dosimeters (OSL's), (Landauer, Glenwood, IL.) placed at 23 head and neck sites. Leaded glasses (LG-600 Rayshield; Aadco Medical, Randolph, VT.) tanning glasses with 1/16" Pb shielding, tanning glasses with lead foil were placed over the phantoms eyes in conjunction with a thyroid collar. NanoDots were placed over the phantoms eyes. No protective equipment was used as a control (NGNS). Radiation exposure was performed using manufacturers predetermined exposure settings. The parameters were 100 kVp, 7 mA, and 9.4 seconds (Table 1). All dosimeters were exposed three times. Exposure values were read using a MicroStar reader (Landauer, Glenwood, IL). All dosimeters were calibrated. Radiation dose fractions to various organ sites were determined using reference values from ICRP-89. Organ equivalent doses were based on ICRP-103 tissue weighting factors. Data analysis was performed using Microsoft Excel.

Table 1: Exposure Parameters

Run ID	Tanning Glasses with 1/16 Pb	Regular Lead Glasses	Tanning Glasses with lead foil	No glasses no shielding
Exposure Time	9.4 sec	9.4 sec	9.4 sec	9.4 sec
kVp	100	100	100	100
mA	7	7	7	7
FOV	80x80	80x80	80x80	80x80
Area Imaged	Full Head	Full Head	Full Head	Full Head
Imaging Machine	Morita X800	Morita X800	Morita X800	Morita X800
Mode	HD	HD	HD	HD
Phantom	Female	Female	Female	Female

Results

Table 2 Tabulates the equivalent dose in µSv for the various organs with the control (NGNS) having the highest effective dose (194.2 µSv) and the tanning glasses with the PB foil the lowest (131.5 µSv). Table 3 gives the average organ dose in µGy using the fraction irradiated factors for all organs measured. As per previous studies all experimental modes indicated high exposure levels for the salivary glands, oral mucosa and extrathoracic airway. Table 4 indicates the average organ dose in µGy with the dose to the lens of the eye ranging from 184.7 µGy (Pb foil) to 363.2 µGy (Control). The per cent reduction to the lens of the eye for the leaded glasses compared to the No Protective Equipmen (Table 5) was 49.2%, 44.6% for tanning glasses with 1/16" Pb shielding and 38.1% for the tanning glasses with lead foil. When considering the effective dose reduction, the tanning glasses with the 1/16" Pb shielding the reduction was 23.4%, for the tanning glasses with lead foil was 32.3%, and the standard leaded glasses hd a reduction of 14.8%. The use of proper PPE is necessary to protect the lens of the eye from possible cataractogenesis.

Table 2: Effective Dose Data

Equivalent Dose µSv					
		Tan Gl/ 1/16 Pb	Reg Pb Gl	Tan Gl/ Pb Foil	No Gl No Shield
Tissue Irradiated	**ICRP-103 Weighting Factor**	**Equiv. Dose (µSv)**	**Equiv. Dose (µSv)**	**Equiv. Dose (µSv)**	**Equiv. Dose (µSv)**
Bone Marrow	0.12	7.93	9.21	9.31	11.89
Thyroid	0.04	12.12	12.98	11.47	25.28
Esophagus	0.04	2.42	2.60	2.29	5.06
Skin	0.01	0.75	0.82	0.64	0.91
Bone Surface	0.01	2.76	3.21	3.24	4.14
Salivary Glands	0.01	83.55	92.70	69.66	98.35
Brain	0.01	1.11	1.14	2.44	2.61
Lymphatic Nodes	0.00923	0.81	0.91	0.69	1.00
Muscle	0.00923	0.81	0.91	0.69	1.00
Extrathoracic Airway	0.00923	10.93	12.31	9.62	13.71
Oral Mucosa	0.00923	25.71	28.52	21.43	30.26
		Eff. Dose (µSv)	**Eff. Dose (µSv)**	**Eff. Dose (µSv)**	**Eff. Dose (µSv)**
Effective Dose	**Eff. Dose µSv**	148.9	165.3	131.5	194.2

Table 3: Average Organ Dose in µGy Using Fraction Irradiated Factors

		Tanning Glasses With 1/16th Pb	Regular Pb Glasses	Tanning Glasses/ Pb Foil	No Glasses
Tissue Irradiated	**Fraction Irradiated**	**µGy**	**µGy**	**µGy**	**µGy**
Bone Marrow	0.154	66.1	76.8	77.6	99.1
Mandible	0.011	30.6	34.0	25.5	36.1
Calvarium	0.116	5.2	5.4	22.9	23.6
Cervical Spine	0.027	30.3	37.4	29.2	39.4
Thyroid	1	303.0	324.4	286.7	631.9
Esophagus	0.2	60.6	64.9	57.3	126.4
Skin	0.05	74.7	81.9	63.7	91.0
Bone Surface	0.154	276.4	320.9	324.3	414.1
Mandible	0.011	128.1	142.1	106.8	150.7
Calvarium	0.116	21.6	22.5	95.7	98.7
Cervical Spine	0.027	126.8	156.3	121.9	164.7
Salivary Glands	1	8355.0	9270.0	6966.0	9834.6
Parotid	1	2785.0	3090.0	2322.0	3278.2
Submandibular	1	2785.0	3090.0	2322.0	3278.2
Sublingual	1	2785.0	3090.0	2322.0	3278.2
Brain	1	111.2	113.6	243.9	260.9
Remainder					

Lymphatic Nodes	0.05	87.5	98.6	75.1	108.1
Muscle	0.05	87.5	98.6	75.1	108.1
Extrathoracic Airway	1	1184.6	1333.8	1043.4	1484.7
Oral Mucosa	1	2785.0	3090.0	2322.0	3278.2

Table 3 (a): Average Organ Dose In µGy

Tissue Irradiated		µGy	µGy	µGy	µGy
Bone Marrow					
Mandible		2785.0	3090.0	2322.0	3278.2
Calvarium		44.5	46.5	197.3	203.6
Cervical Spine		1123.1	1385.0	1080.0	1459.2
Thyroid		303.0	324.4	286.7	631.9
Esophagus		303.0	324.4	286.7	631.9
Skin		1493.0	1637.4	1273.3	1820.7
Bone Surface					
Mandible		11641.3	12916.2	9706.0	13702.9
Calvarium		186.0	194.4	824.8	851.0
Cervical Spine		4694.7	5789.3	4514.4	6099.5
Salivary Glands					
Parotid		2785.0	3090.0	2322.0	3278.2
Submandibular		2785.0	3090.0	2322.0	3278.2
Sublingual		2785.0	3090.0	2322.0	3278.2
Brain		111.2	113.6	243.9	260.9
Remainder					
Lymphatic Nodes		1749.0	1972.4	1502.7	2161.9
Muscle		1749.0	1972.4	1502.7	2161.9
Extrathoracic Airway		1184.6	1333.8	1042.4	1484.7
Oral Mucosa		2785.0	3090.0	2322.0	3278.2
Lens of Eye		201.0	184.7	224.5	363.2

Table 4: Equivalent Dose in µSv

Equivalent Dose µSv					
		Tan Gl/ 1/16 Pb	Reg Pb Gl	Tan Gl/ Pb Foil	No Gl No Shield
Tissue Irradiated	ICRP-103 Weighting Factor	Equiv. Dose (µSv)	Equiv. Dose (µSv)	Equiv. Dose (µSv)	Equiv. Dose (µSv)
Bone Marrow	0.12	7.93	9.21	9.31	11.89
Thyroid	0.04	12.12	12.98	11.47	25.28
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Skin	0.01	0.75	0.82	0.64	0.91
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Brain	0.01	1.11	1.14	2.44	2.61
Lymphatic Nodes	0.00923	0.81	0.91	0.69	1.00
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Extrathoracic Airway	0.00923	10.93	12.31	9.62	13.71
Oral Mucosa	0.00923	25.71	28.52	21.43	30.26
		Eff. Dose (µSv)	Eff. Dose (µSv)	Eff. Dose (µSv)	Eff. Dose (µSv)
Effective Dose	Eff. Dose µSv	148.9	165.3	131.5	194.2

Table 5: Lens of Eye Dose and Percentage Dose Reduction

	No Glasses,no thyroid shield	Lead Glasses, thyroid shield	Tanning Glasses/lead foil, thyroid shield	Tanning glasses, 1/16 Pb, thyroid shield
µGy	363.2	184.7	224.5	201.1
% Reduction		49.2	38.1	44.6

Discussion

The ICRP and NCRP over the past several decades has reduced the allowable limit on ionizing radiation dose to the lens of the eye for the public from 50 mSv/year to 15 mGy/year. As more and more data from existing research was obtained the level of ionizing radiation to the lens of the eye has been gradually reduced. This includes the period from 1954 to the latest downgrade in 2016. The ICRP has not assigned a tissue weighting factor to the lens of the eye over all these years due to the difficulty obtaining reliable data.

The current state of the effect of ionizing radiation to the lens of the eye is dependent on changes in the epithelial cells in the lens of the eye which could result in caterogenisis. Who knows what effect low level exposure from CBCT can have on the lens of the eye and cataract formation. As more data is obtained there is a possibility that multiple exposures to low level ionizing radiation from CBCT procedures can be a factor. Therefore we are proposing using some sort of shielding for the lens of the eye, hence the use of tanning glasses with either Pb shielding or lead foil. Regular leaded glasses are best, but they could interfere with anatomical features that are necessary for some dental procedures plus we have shown that there is secondary radiation produced when the larger leaded glasses are used.

Conclusions

The lens of the eye is one of the most sensitive organs in response to ionizing radiation. Here we have shown that the use of leaded glasses and tanning glasses with Pb or lead foil reduced the dose to the lens of the eye by 38.1 to 49.2%. In light of recent articles by Hamada and Barnard on the effects of ionizing radiation to the epithelial cells and DNA of the lens of the eye further research is warranted.

References

1. ICRP (1951) International recommendations on radiological protection. Br J Radiol 24: 46-53. https//doi.org/10.1259/0007-1285-24-277-46.
2. ICRP (1977) Recommendation of the International Commission on radiological protection. ICRP publication 26. Ann ICRP 1: 1-80.
3. ICRP (2007) Recommendation of the International Commission on radiological protection. ICRP publication 103. Ann ICRP 37: 1-322.
4. ICRP (2012) Recommendation of the International Commis-

sion on radiological protection. ICRP publication 118. ICRP statement on tissue reactions and early and late effets of radiation in normal tissues and organs-threshold doses for tissue reactions in a radiation protection context. Ann ICRP 41: 1-322. https//doi.org/10.1016/j.icrp.2012.02.001.

5. Dauer LT, Elizabeth A Ainsbury, Joseph Dynlacht, David Hoel, Barbara E K Klein, et al. (2017) Guidance on radiation dose limits for the lens of the eye: overview of the recommendations in NCRP Commentary No. 26. Int J Radiat Biol 93: 1015-1023. https//doi.org/10.1080/09553002.2017.1304669.
6. Goren AD, Prins RD, Dauer LT, Quinn B, Al-Najjar A, et al. (2013) Effect of lead glasses and thyroid shielding on CBCT radiation dose in an adult female phantom. Dentomaxillofacial Radiol 42: 2012060.
7. Prins RD, Dauer LT, Colosi DC, Quinn B, Kleiman NT, et al. (2011) Significant reduction in dental CBCT eye dose through the use of leaded glasses. OSOMOPOR&E 112: 502-507.
8. Hamada N, Azizova T, Little MP (2020) An update on effects of ionizing radiation exposure on the eye. Br J Radiol 93: 20190829.
9. Barnard SGR, McCarron R, Moquet J, Quinlan R, Ainsbury E (2019) Inverse dose-rate effect of ionizing radiation on residual 53BP1 foci in the eye lens. Scientific Reports 9: 10418. https://doi.org/10.1038/s41598-019-46893-3.