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# Dose Reduction Using the dexshield™ Rectangular Collimator in Dental Radiography

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## Abstract

**Background:** Rectangular collimation has been recommended by both the ADA and the NCRP to significantly reduce patient exposure to ionizing radiation. Various types of rectangular collimation devices have been devised, but the dose reduction to various organs of the head and neck and overall total dose reduction has not been evaluated.

**Objective:** To provide dosimetric data on four bitewing X-ray exposures to head and neck organs of a female CIRS anthropomorphic phantom using round and rectangular (DEXshield™) collimation for digital imaging.

**Materials and methods:** Dose measurements were obtained using Optically Stimulated Luminescent (OSL) dosimeters placed in pre-manufactured slots of an anthropomorphic female CIRS phantom. The phantom had removable cutouts for bilateral placement of a digital sensor at the bitewing level. Four bitewing radiographs were acquired using a Gendex 765 X-ray machine at three settings using round and rectangular (DEXshield™) collimation. All exposures were repeated 15 times for each of the four bitewing exposures. The organ fractions irradiated were determined from ICRP-89 reference phantoms according to age. kVp factors and ICRP-103 tissue weighting factors were also applied.

**Results:** Overall, an average of between 28-47.5% dose reductions when using the shield. The highest reductions for all exposures were for the eyes, cranium and brain. The 0.08 second exposure yielded the highest dose reduction and the 0.80 second exposure the least reduction.

**Conclusion:** Our data indicated that the DEXshield™ significantly reduced unnecessary radiation dose to organs of the head and neck.

**Keywords:** Dose measurements; DEXshield™; Dose reductions; Radiography

## Background

Rectangular collimation has been recommended by the American Dental Association (ADA), the National Council on Radiation Protection and Measurement (NCRP), and the International Council on Radiation Protection (ICRP) for use in dental intraoral radiography to reduce patient exposure from ionizing radiation [1-4]. Over the past decades, various types of rectangular collimating devices have been developed to significantly reduce patient exposure [5-7]. However, organ dose reduction due to scatter of the primary radiation beam has not been evaluated for any of the rectangular collimation devices.

Optically stimulated luminescent dosimetry (OSL) technology has been shown to be at least 20% more sensitive than thermo luminescent dosimetry (TLDs) at dental radiation levels [8-10]. The Micro Star In light Nano Dot Dosimeters (Landauer, Glenwood, IL) measure radiation exposure using aluminum oxide ($Al_2O_3$:C) detectors. The amount of light released upon stimulation of the detector by a light emitting from the array is directly proportional to the radiation dose to which the detector has been exposed.

## Objective

To provide dosimetric data on four bitewing X-ray exposures to head and neck organs of a female CIRS® anthropomorphic phantom using round and rectangular (DEXshield™) collimation for digital imaging.

## Materials and Methods

Dose measurements were obtained using Optically Stimulated Luminescent (OSL) dosimeters placed inpre-manufactured slots at the location of 27 head and neck anatomic structures of an anthropomorphic female CIRS® phantom (CIRS®, Inc. Norfolk, VA). The phantom had removable cutouts for bilateral placement of a digital sensor (Dexis) at the bitewing level (Figure 1). Four bitewing exposures were acquired using a Gendex 765DC X-ray machine (Gendex, Milan, Italy) at 65 kVp, 7 mA at three different exposure settings (0.08, 0.32 and 0.80 seconds) using round collimation alone and round collimation with the DEXshield™ (Imaging Science International. Hatfield, PA) attached (Figure 2). All exposures were repeated 15 times for each of the four bitewing positions (60 exposures). The results were divided by 60 to evaluate the average dose. Replicate exposure conditions and positioning that the average dental practitioner would employ were created. The organ fractions irradiated were determined from ICRP-89 reference phantoms according to age. kVp factors were also applied and all OSL exposures were read on a calibrated Landauer MicroStar reader.

## Results

The organ dose for the shielded and unshielded collimation using the Dex is sensor and the DEXshield™ is shown in mrads in table 1. The highest reductions for all exposures were for the eyes, cranium and brain. Overall there was an average of between 28-47.5% reductions when all

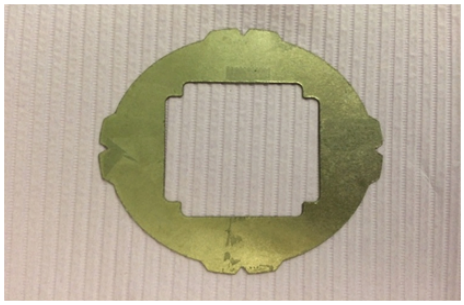

**Figure 1**: Phantom with bitewing cutouts


**Figure 2:** DEXshield

| Image Receptor | DEXIS | DEXIS | DEXIS | DEXIS | DEXIS | DEXIS |
|---|---|---|---|---|---|---|
| Shield=S, No-Shield=NS | NS | S | NS | S | NS | S |
| Exposure Time (s) | 0.08 | 0.08 | 0.32 | 0.32 | 0.80 | 0.80 |
| kVp/mA | 65/7 | 65/7 | 65/7 | 65/7 | 65/7 | 65/7 |
| # of Views | 4 | 4 | 4 | 4 | 4 | 4 |
| Organ | Avgmrad | Avgmrad | Avgmrad | Avgmrad | Avgmrad | Avgmrad |
| Mandible | 53.96 | 35.86 | 239.80 | 162.54 | 166.84 | 77.85 |
| Brain | 0.71 | 0.41 | 1.83 | 1.26 | 5.87 | 2.54 |
| Cranium | 0.47 | 0.26 | 1.11 | 0.62 | 2.63 | 0.99 |
| C-Spine | 3.21 | 2.33 | 13.54 | 10.49 | 13.64 | 8.46 |
| Thyroid | 1.77 | 1.34 | 7.14 | 5.57 | 13.60 | 9.42 |
| Eye | 14.09 | 4.68 | 42.56 | 9.46 | 231.77 | 30.78 |

**Table 1:** Organ dose for shielded and unshielded collimator

organs were considered. Table 2 shows the average per cent difference for the No Shield vs. Shield at three different exposure times. The highest dose reduction, 39.1% was for the 0.08 second exposure and the 0.80 second exposure the least reduction 36.6%. The average reduction for all three exposure times was 37.7%.

## Conclusion and Discussion

These data indicated that the DEXshield™ significantly reduced unnecessary radiation dose to the organs of the head and neck. By restricting the primary and secondary radiation to which a patient is exposed, rectangular collimation is the most effective method of dose reduction a practitioner can utilize.

The DEXshield™ is a unique dental x-ray position indicating device (PID) when used during imaging procedures. It aligns the x-ray beam with desired imaging site and provides an attenuating barrier to protect

| Type of Image Receptor | DEXIS | DEXIS | DEXIS |
|---|---|---|---|
| Shield=S, No Shield=NS | NS:S | NS:S | NS:S |
| Exposure Time (s) | 0.08 | 0.32 | 0.80 |
| kVp.mA | 65.7 | 65.7 | 65.7 |
| # of Reps | 60 | 60 | 40 |
| Control (mrad) | 16.5 | 16.5 | 16.5 |
| | Avg % Difference | Avg % Difference | Avg % Difference |
| Mandible | -33.4 | -28.2 | 7.8 |
| Brain | -41.9 | -31.0 | -45.7 |
| Cranium | -44.9 | -42.5 | -37.6 |
| C-Spine | -22.3 | -31.2 | -5.4 |
| Thyroid | -24.1 | -21.7 | -28.6 |
| Eye | -67.4 | -77.7 | -69.7 |
| All Locations | -39.1 | -37.3 | -36.6 |

**Table 2:** Per cent reduction for DEXshield at three different exposure times

the patient from unnecessary radiation. The DEXshield™ is a true all-in-one positioning device that allows the dental practitioner to capture both periapical and bite wing radiographs using a single device. DEXshield™ replaces the positioning ring that comes with the PID Universal Ring and reduces the radiation to the patient by at least 30%. Also the DEXshield™ is easier to use than rectangular collimation. It also reduces the possibility of cone cuts, missed apices, and malpositioning by allowing the operator to establish correct positioning and alignment.

## Conflict of Interest

This study was supported by a grant from Imaging Sciences International.

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