RESEARCH ARTICLE

Dose reduction in orthodontic lateral cephalography: dosimetric evaluation of a novel cephalographic thyroid protector (CTP) and anatomical cranial collimation (ACC)

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Objectives: To test the dose-reducing capabilities of a novel thyroid protection device and a recently introduced cranial collimator to be used in orthodontic lateral cephalography.

Methods: Cephalographic thyroid protector (CTP) was designed to shield the thyroid while leaving the cervical vertebrae depicted. Using a RANDO[®] head phantom (The Phantom Laboratory, Salem, NY) equipped with dosimeters and a Proline XC (Planmeca, Helsinki, Finland) cephalograph, lateral cephalograms were taken, and the effective dose (ED) was calculated for four protocols: (1) without shielding; (2) with CTP; (3) with CTP and anatomical cranial collimator (ACC); and (4) with a thyroid collar (TC).

Results: The ED for the respective protocols was (1) 8.51; (2) 5.39; (3) 3.50; and (4) 4.97 μ Sv. The organ dose for the thyroid was reduced from 30.17 to 4.50 μ Sv in Protocols 2 and 3 and to 3.33 μ Sv in Protocol 4.

Conclusions: The use of just the CTP (Protocol 2) resulted in a 36.8% reduction of the ED of a lateral cephalogram. This was comparable to the classical TC (Protocol 4). A 58.8% reduction of the ED was obtained when combining CTP and ACC (Protocol 3). The dose to the radiosensitive thyroid gland was reduced by 85% in Protocols 2 and 3 and by 89% in Protocol 4.

Dentomaxillofacial Radiology (2015) **44**, 20140260. doi: [10.1259/dmfr.20140260](https://doi.org/10.1259/dmfr.20140260)

Cite this article as: Hoogveen RC, Rottke D, van der Stelt PF, Berkhouit WER. Dose reduction in orthodontic lateral cephalography: dosimetric evaluation of a novel cephalographic thyroid protector (CTP) and anatomical cranial collimation (ACC). *Dentomaxillofac Radiol* 2015; **44**: 20140260.

Keywords: thyroid gland; radiation protection; orthodontics; dosimetry; cephalometry

Introduction

Lateral cephalograms are radiographs that are frequently used to plan and evaluate orthodontic treatment. The use of X-rays is considered to be potentially harmful, so clinicians are obliged to use X-rays prudently to ensure that the dose for the patient is “as low as reasonably achievable”.¹ One possible way to reduce the dose for the patient is by minimizing the irradiated area of the patient to the region of interest for the diagnostic task. Recently, the anatomical cranial

collimator (ACC) was introduced to shield the area cranial of the skull base from radiation.² This cranial area is without diagnostic information to the orthodontist. Another area that is in the field of view of lateral cephalograms without diagnostic information is the thyroid region. The thyroid gland is one of the most radiosensitive organs in the head and neck region. The thyroid region does not contain diagnostic information for dental or orthodontic treatment. Therefore, attention should be paid not to expose this area to radiation during cephalography as elevated risk of thyroid cancer following external radiation has been demonstrated.^{3–5} Depending on the size of the

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This work was supported by Academic Center for Dentistry ACTA.

Received 27 July 2014; revised 19 December 2014; accepted 6 January 2015

patient and the collimation of the beam, the thyroid is partially or completely irradiated during a cephalographic exposure when no shielding measures are taken.⁶ The European guidelines on the safe use of radiographs in dental practice read: “in cephalometric radiography lead thyroid protection is necessary if the beam collimation does not exclude the thyroid gland”.¹ The US guidelines as formulated by the National Commission on Radiological Protection also recommend thyroid protection: “Thyroid shielding shall be provided for children, and should be provided for adults, when it will not interfere with the exam”.⁷ The differentiation between children and adults can be explained by the fact that children are at higher risk of detrimental effects of radiation per administered dose.⁶

The majority of persons undergoing orthodontic treatment are children, and the prevalence of orthodontic treatment is high in westernized societies.⁸ Several cephalograms are usually taken during orthodontic treatment.⁹ These exposures individually result in a low dose of 5–10 μ Sv when using modern X-ray equipment, but the high number of these exposures together adds up to a considerable collective dose.^{10,11} This is considered to be a significant potential health issue.¹² In their 2013 policy statement “Thyroid shielding during diagnostic medical and dental radiology”,¹³ the American Thyroid Association suggests a connection between the rise in the radiation burden of the thyroid gland and the rising prevalence of thyroid cancers. The American Thyroid Association recommends that efforts should be made to encourage and monitor compliance with medical and dental guidelines with respect to shielding the thyroid gland.¹³

Thyroid collars (TCs) to shield the thyroid gland during lateral cephalography were first introduced by Block *et al*¹⁴ in 1977 and are readily available. Wiechmann *et al*¹⁵ have investigated the utility of TCs and concluded “TCs should be routinely applied during cephalometric radiography if cephalometric analyses are limited to structures above the second cervical vertebra”. In 2011, Sansare *et al*¹⁶ came to a similar conclusion that TCs should be used unless information on the morphology of the cervical vertebrae is needed to perform a skeletal maturity index (SMI). SMI was introduced by Hassel and Farman¹⁷ as an alternative to the use of hand–wrist exposures to assess skeletal maturation used to determine timing and possibilities for growth modification of orthodontic treatment. It was further developed and popularized by Franchi *et al*¹⁸ from the onset of this century.¹⁹ Although the validity of the use of SMI is debated, it may be one of the reasons why compliance with shielding the thyroid gland is poor.^{3,20} Hujoel *et al* found a drop in TC use from almost 50% in the 1990s to as low as 10% in the beginning of this century. Hujoel *et al*⁶ suggest that this decrease is connected to the rise in use of SMI. In the third edition of the guidelines of the British Orthodontic Society (2008), Isaacson *et al*²¹ stated that hand–wrist exposures are no

longer indicated because cervical vertebrae could provide the needed maturation information, thereby discouraging the use of TCs. Recently, Patcas *et al*¹¹ conducted a dose study in which it was shown that the effective dose (ED) of a cephalogram when used with a TC plus an additional hand–wrist exposure is >30% lower than that of a single cephalogram with the cervical area exposed. This author strongly advocates the use of TCs and the use of an additional hand–wrist exposure if evaluation of skeletal age is needed.

The authors of this present article reasoned that resistance to shielding the thyroid gland would be eliminated if a device would be available that shields the thyroid gland without obscuring the cervical vertebrae. This could lead to improvement in compliance with the guidelines. To be able to justify the costs of such a shielding device, dosimetry is needed to establish the dose-reducing capabilities of the device.

The aim of this study is to (1) present a thyroid-shielding device that leaves the cervical vertebrae exposed during lateral cephalography and to test its dose reducing capabilities compared with a TC and (2) to test the dose reduction of the device in combination with anatomical cranial collimation.

Methods and materials

Design of the cephalographic thyroid protector

For the design of the cephalographic thyroid protector (CTP), the correct dimensions of the shielding pad and the correct positioning of the device to the side of the neck of the patient had to be determined.

The dimensions of the shielding pad were determined with the aid of lateral extraoral light photographs with shielding pad dummies of different sizes and shapes positioned on the neck of patients for whom recent cephalograms were available. By superimposing these light photographs with the cephalograms of these same patients, the optimal form, size and position of a shielding pad could be determined in several iteration steps.

The corresponding shielding pad, including a slab of 1-mm thick lead in a matching plastic casing, was designed using SolidWorks three-dimensional computer-aided design software v. 2011 (Dassault Systèmes SolidWorks, Waltham, MA).

To stabilize this shielding pad to the side of the neck of a patient during image acquisition, a flexible arm was attached and fitted with a plastic neck rest that was on the contralateral posterior corner of the neck; these items together formed the CTP (Figures 1 and 2). The plastic components were fabricated through selective laser sintering of PA 2200 material on a dedicated Electric Optical System system (EOS GmbH Electro Optical Systems, Munich, Germany). The parts were joined and assembled with gluing and regular fasteners.

Figure 1 Photographs of the cephalographic thyroid protector (CTP) positioned on the neck of a patient in a cephalostat, and the anatomical cranial collimator (ACC) fixed to the ear post of the cephalostat viewed from frontal and lateral sides. On the lateral view, a marking can be seen that helps to correctly position the CTP. The marking should be parallel to the anterior border of the sternocleidomastoid muscle; the corner of the CTP pointing upwards should be in close proximity to the angle of the mandible.

Dose measurements

An anthropomorphic adult RANDO[®] head phantom (The Phantom Laboratory, Salem, NY) was placed in a Proline XC device (Planmeca, Helsinki, Finland) with a “single shot” lateral cephalometric option. To place thermoluminescent dosimeters (TLDs) in the phantom head, holes were drilled at 25 specific locations. The locations that were used are specified in Table 1. At each location, two solid TLD GR 200A chips (Thermo Fisher Scientific, Waltham, MA) were placed. According to the manufacturer’s data sheet, the TLDs were accurate in the range of 0.1 μ Gy–10 Gy. To preserve the TLD chips from any contamination, they were placed in polymethyl methacrylate containers. For transposition of the TLD, a vacuum forceps (Aspirette[®]; Hirschmann Laborgeräte, Eberstadt, Germany) was used. The total number of TLDs used per protocol was 50. Three additional dosimeters per protocol were kept apart to facilitate correction for background radiation or other possible unknown influencing factors. After placing two TLDs at each location, the RANDO phantom was reassembled and aligned in the cephalostat of the cephalometric X-ray unit. Great care was taken to assure that the phantom was positioned identically during all four protocols.

To reset and anneal all TLDs at the same time and in a reproducible procedure, a microprocessor-controlled TLD oven (PTW-Freiberg, Freiberg, Germany) was used; before the exposure, all TLDs were heated to 220 °C,

were kept at this temperature for 15 min and cooled down to room temperature. The readout process of the TLD was performed in a Fimel LTMWin oven (Fimel, Fontenay-aux-Roses, France). Each TLD was placed in the oven, and the readout process was initialized, and

Figure 2 Lateral cephalogram made with cephalographic thyroid protector (CTP) and anatomical cranial collimator (ACC).

Table 1 Locations of the pairs of thermoluminescent dosimeters

Location	Tissue	Location
1	Skull	Left
2	Skull	Right
3	Brain	Left
4	Brain	Right
5	Orbital floor	Left
6	Orbital floor	Right
7	Mandibular ramus ascendens	Left
8	Mandibular ramus ascendens	Right
9	Parotid gland	Left
10	Parotid gland	Right
11	Mandibular body	Left
12	Mandibular body	Right
13	Submandibular gland	Left
14	Submandibular gland	Right
15	Oesophagus	Left
16	Oesophagus	Right
17	Cheek	Left
18	Cheek	Right
19	Thyroid surface	Left
20	Thyroid surface	Right
21	Thyroid intern	Central
22	Neck (muscle)	Central
23	Cervical vertebrae	Central
24	Floor of the mouth	Central
25	Skull anterior	Central

the result of the process, a digit representing the detected radiation energy by the TLD (A_{det}), was displayed and stored.

All TLDs were cross-calibrated through an exposure with a defined dose (D_{def}) of $1.01 \times 10^5 \mu\text{Gy}$, which was measured using a UNIDOS[®]E (PTW) that was calibrated at PTW, Freiburg, Germany (SSD Laboratory). After the readout process, the detected energy (A_{det}) was used to calculate an individual calibration factor K_i (Equation 1).

$$K_i = \frac{D_{\text{def}}}{A_{\text{det}}} \tag{1}$$

All individual calibration factors K_i were averaged to a mean calibration factor $K = 3.58 \times 10^{-3}$ [standard deviation (SD) = 1.12×10^{-4} , relative SD (SD%) = 3.2%].

The evaluation of the ED was performed using four different protocols in lateral cephalometric mode with different shielding devices with constant technique factors (Table 2).

After scanning, the RANDO phantom was deconstructed, and the readout process was performed immediately.

To calculate the ED each .TXT file from the read-out process was imported to Microsoft[®] Excel[®]: Mac 2011 v. 14.4.4 (Microsoft Corporation, Redmond, WA). All calculations were also carried out using this version of Excel.

The technique factors used for a single exposure for an adult female in our institute are 80 kV, 12 mA and 0.6 s exposure time with 2.5-mm aluminium filtration. To obtain reliable measurements, exposures were made with 80 kV, 12 mA and a total exposure time of 250 s

(50 exposures of 5 s) for every protocol. These selected technique factors gave an equivalent number of $n = 416.7$ regular exposures ($n = 250/0.6$).

The absorbed dose at each of the 25 locations (s) within the RANDO phantom was calculated by averaging the A_{det} of the two dosimeters of that location (Equation 2).

$$AD_{\text{measured}}^s = \frac{K \times \left\{ \frac{1}{2} \times (A_{\text{det}}\text{TLD})_1^s + (A_{\text{det}}\text{TLD})_2^s \right\} - A_{\text{det}}\text{TLD}^{\text{BR}}}{416.7} \tag{2}$$

where $(A_{\text{det}}\text{TLD})_1^s$ and $(A_{\text{det}}\text{TLD})_2^s$ are the energies detected in Dosimeters 1 and 2 at location (s), and $A_{\text{det}}\text{TLD}^{\text{BR}}$ is the energy detected by the background dosimeters, multiplied by the calibration factor K , divided by the number of regular exposures ($n = 416.7$).

Subsequently, to calculate the equivalent dose for the organ/tissue (H_{tissue}), all absorbed doses for the locations representing one tissue were averaged. Which locations were used for which tissues is specified in Table 3. These averaged doses were corrected for the proportion of the presence of this tissue/organ within the exposed area in relation to the whole human body (λ_{tissue}) as shown in Equation 3. The proportions used in these calculations are shown in Table 3. Both the locations and the proportion used were based on International Commission on Radiological Protection recommendations.²²

$$H_{\text{tissue}} = \lambda_{\text{tissue}} \times \frac{1}{s \in \text{tissue}} \sum_{s \in \text{tissue}} AD_{\text{measured}}^s \tag{3}$$

The ED in total was then calculated using the proposed weighting factors ω_{tissue} from the International Commission on Radiological Protection 103, published in 2007 shown in Table 3.²² The ED is the summation of the equivalent doses (H_{tissue}) multiplied by their tissue/organ-weighting factors (ω_{tissue}), multiplied by the radiation weighing factor $\omega_{\text{radiation}}$. This radiation-weighting factor is 1 for X-rays (Equation 4).

$$ED = \sum_{\text{tissue}} \omega_{\text{tissue}} \times H_{\text{tissue}} \times \omega_{\text{radiation}} \tag{4}$$

Error calculation

A mathematical approach to calculate error propagation of the random error found in the measurements of

Table 2 Shielding and technique factors for the different protocols

Protocol	Shielding	Voltage (kV)	Current (mA)	Exposure time (s)
1	None	80	12	50 × 5
2	CTP	80	12	50 × 5
3	CTP + anatomical cranial collimator	80	12	50 × 5
4	Thyroid collar	80	12	50 × 5

CTP, cephalographic thyroid protector.

Table 3 Tissue weighting factors and percentage of the tissues exposed according to International Commission on Radiological Protection (ICRP) publication 103²² and the numbers of which locations (Table 1) were used to calculate the organ or tissue doses

Tissue	ICRP tissue-weighting factors	Fraction irradiated (%)	Locations used to calculate the organ dose
Bone marrow	0.12	16.5	1, 2, 7, 8, 11, 12, 23, 25
Remainder tissues			
Extrathoracic airway	0.12	100	5, 6, 13–16, 21, 24
Lymphatic nodes	0.12	5	5, 6, 9, 10, 13–16
Muscle	0.12	5	5, 6, 9, 10, 13, 14, 21, 22, 25
Oral mucosa	0.12	100	13, 14, 24
Oesophagus	0.04	10	15, 16
Thyroid	0.04	100	19–21
Bone surface	0.01	16.5	1, 2, 7, 8, 11, 12, 23, 25
Brain	0.01	100	3, 4
Salivary glands	0.01	100	9, 10, 13, 14, 24
Skin	0.01	5	17, 18

our experiments was not feasible. This is because the equivalent dose that is calculated for one organ in many cases is derived from locations that are also used for calculation of the equivalent doses of other organs. This means that they are not independent and that the rules of error propagation cannot be readily used because of these dependent random errors. A viable way to estimate the random error in the ED is to use “Monte Carlo” simulation. To perform this simulation, open source software R v. 3.0.2 (The R Foundation for Statistical Computing, Vienna, Austria) was programmed to exactly simulate the ED calculation algorithm used in this experiment. 10,000 cycles of ED calculation per protocol were simulated. For every single cycle, the software generated values in the calculation that contained random error. These values were based on the measured values found in the present experiment and their calculated SDs. As our data clearly showed a significant quadratic relationship between the relative error in the TLD measurements [measured as relative SD = $SD\% = (SD/\text{mean}) \times 100\%$] and the amount of energy they detected (A_{det}) to $p = 0.001$ with $r^2 = 0.126$. The generation of this was modelled as a quadratic function (Equation 5).

$$SD\% = 4.57 - 1.98 \times 10^{-7} \times (A_{\text{det}}) + 3.29 \times 10^{-15} \times (A_{\text{det}})^2 \quad (5)$$

By assessing the 10,000 ED outcomes, the SD in the ED calculation of a protocol could be established. These SDs were used to evaluate significance between the ED of different protocols ($p < 0.05$).

Results

The calculated ED for the protocols and their SDs generated by the simulations are displayed in Table 4. The ED without shielding was $8.51 \mu\text{Sv}$ (SD, 0.099). The differences between the “no shielding” protocol and the three shielding protocols are shown in Table 5. All differences between the protocols were significant. The organ that received the highest dose in Protocol 1 was

the thyroid gland with $30.17 \mu\text{Sv}$. The thyroid dose was reduced by the CTP in Protocols 2 and 3 to $4.50 \mu\text{Sv}$ (85% reduction) and in Protocol 4 to $3.33 \mu\text{Sv}$ (–89%).

Discussion

A device (CTP) that shields the thyroid gland while leaving the cervical vertebrae exposed to facilitate SMI was introduced. The rise of the popularity of the SMI is seen as one of the reasons for not complying with the guidelines on shielding the thyroid from the primary beam. By making a device available that shields the thyroid while leaving the vertebrae visible, the compliance could be improved. CTP can only be considered a viable alternative when its dose reduction capabilities are comparable to that of a TC. In this dose study, it was established that dose reduction of CTP was somewhat lower but comparable with that of a TC. The fact that the CTP shields a smaller area than does the TC may explain this.

In a recent study by Patcas *et al*,¹¹ an ED reduction of 34% was found when the thyroid area was shielded with a TC. This is comparable to the findings in this study. Patcas *et al* strongly recommend shielding of the thyroid and the taking of an additional hand–wrist exposure if skeletal maturation information is needed. This additional hand–wrist radiograph is not necessary when using the CTP instead of TC. On the other hand, when no information on skeletal maturation is desired, the TC should be preferred because it shields a larger area and was found to reduce the ED more.

When the thyroid is shielded, the further reduction of the exposed area cranial of the skull base with the ACC reduces the ED with an additional 35%. The ACC covers a larger area than does the CTP but the tissues that are shielded are less radiosensitive than those in the thyroid area. A reduction of more than a third is remarkable with this fixed one-size-fits-all collimator. A validation study of the cranial collimator revealed that relevant diagnostic information is not shielded when this device is used.²³

Table 4 Absolute and relative effective dose (ED) calculated for the different tissues involved

Tissue	Protocol 1: no shielding		Protocol 2: CTP		Protocol 3: CTP and ACC		Protocol 4: TC	
	ED [μSv] (SD)]	ED% (SD%)	ED [μSv] (SD)]	ED% (SD%)	ED [μSv] (SD)]	ED% (SD%)	ED [μSv] (SD)]	ED% (SD%)
Bone marrow	1.61	18.95	1.44	26.70	0.53	15.25	1.50	30.13
Oesophagus	0.22	2.52	0.20	3.77	0.17	4.88	0.04	0.75
Thyroid	3.62	42.49	0.54	10.07	0.54	15.46	0.40	7.96
Bone surface	0.14	1.58	0.12	2.22	0.05	1.27	0.13	2.51
Brain	0.55	6.47	0.56	10.41	0.08	2.45	0.57	11.43
Salivary glands	0.86	10.10	0.98	18.09	0.84	24.05	0.98	19.54
Skin	0.04	0.46	0.05	0.98	0.05	1.22	0.05	1.06
Remainder tissues	1.49	17.43	1.49	27.77	1.25	35.42	1.32	26.62
Total ED	8.51 (0.099)	100 (1.16)	5.39 (0.059)	100 (1.10)	3.50 (0.041)	100 (1.18)	4.97 (0.059)	100 (1.18)

ACC, anatomical cranial collimator; CTP, cephalographic thyroid protector; SD, standard deviation; SD%, relative SD; TC, thyroid collar.

For the different tissues, the ED is the equivalent dose (H_{tissue}), corrected for the fraction of the tissue in the exposed area and corrected for the tissue-weighting factor (w_{tissue}).

The total ED is the summation of these EDs of the different tissues.

The reduction of the combination of the two devices results in an almost 60% reduction of the dose. In the literature, we find an article by Gijbels *et al.*²⁴ from 2003 where collimation of non-diagnostic areas on a cephalogram resulted in 40% dose reduction using a phantom head. Alcaraz *et al.*²⁵ also investigated the dose reduction collimator to be used in combination with a combined panoramic–cephalometric machine. They reported ED reductions around 60%, which is comparable to our result. Lee *et al.*²⁶ using Monte Carlo simulation and dose measurements to evaluate a collimator similar to that of Gijbels *et al.*²⁴ also found around 60% ED reduction. From the literature, it can be concluded that only 40% of the ED of a non-collimated cephalogram contributes to its diagnostic value. A fifth protocol to investigate the ED reduction of TC combined with the ACC was considered but was discarded because of time and financial constraints. When we consider the changes in organ doses caused by the shielding of the different areas in the different protocols, it can be deduced that the reduction of ED for the combination of ACC and TC would be around 65%. The reduction in the thyroid dose of 85% by the CTP is striking. The thyroid is the most radiosensitive organ in the head and neck region. As these substantial reductions can be reached without loss of diagnostic information, clinicians should seriously consider implementation of using these devices.

The relative error in the measurements was found to be small, between 1.1% and 1.2%. This was assessed using multiple recalculations of the ED with random error generated by software. As far as the authors

know, this way of estimation of the error of dosimetric research was not carried out before. In order to be able to make statements on significance of the differences between the protocols, a valid assessment of the error in the experiment seems vital to the authors. This way of estimating error could also be used in the set-up of dosimetric studies. It could, for example, be used to decide if one or two dosimeters are needed per location. In the case of this experiment, the use of one dosimeter per location, instead of two, would have enlarged the error in our ED results to 1.23–1.35%. The error found resulted in significance between the ED calculated from the different protocols. The small error found in this experiment does not imply that the science of ED calculations in larger scope is very precise. The ED calculation originally was introduced for radiation protection purposes. More and more ED is used to evaluate and compare medical exposures with greater precision than the underlying science justifies. Martin²⁷ states in an article on the use of the ED concept for medical exposures that the relative uncertainties might be around 40%. This being the case, in a controlled experiment as in the present article, these uncertainties are identical for the protocols that are compared and therefore not relevant for these comparisons.

The phantom head used in this study was adult sized. The dose calculations made with the technique factors suggested by the manufacturer for an adult resulted in the reported ED of 8.51 μSv . Ideally, the study would have been carried out with an adolescent or child size phantom, which was unfortunately not available for this

Table 5 Relative differences between the four protocols

Protocol	Effective dose (μSv)	Difference to Protocol 1 (%)	Difference to Protocol 2 (%)	Difference to Protocol 3 (%)	Difference to Protocol 4 (%)
1. No shielding	8.51	0	+57.9	+142.8	+71.0
2. CTP	5.39	−36.7	0	+53.7	+8.3
3. CTP + anatomical cranial collimator	3.50	−58.8	−34.9	0	−29.6
4. Thyroid collar	4.97	−41.5	−7.6	+41.9	0

CTP, cephalographic thyroid protector.

study. The results for ED reduction in the same experiment with a child phantom can be expected to be comparable as the same organs are shielded. Possibly the reduction might be even greater as the shielding devices are covering a greater part of a child's head. In our clinic, the technical factors are used with a shorter exposure time of 0.4 s for children. This would arbitrarily correspond to 5.7 μ Sv child dose without shielding. This is a dose that is comparable to those found in the literature.¹⁰ With the maximum shielding, as in Protocol 3, this value would be reduced to 2.3 μ Sv. This is an ED comparable to that of two bitewing exposures with rectangular collimation. In more modern equipment than that used in the present study, this value could be even lower. More interesting than the absolute values of the exposures in this specific cephalometric unit are the relative effects. They imply that independent of the radiographic equipment used, whether it delivers a high or a low ED, this ED can be more than halved by adequate shielding.

Given the fact that many cephalographic exposures are made, a serious reduction of the collective dose can

be achieved if these shielding devices are generally used. Because the orthodontic patients are young on average, the risk of this collective dose in the form of cancer induction is higher. This makes the substantial reduction in ED with the shielding devices all the more meaningful.

In conclusion, the ED of orthodontic lateral cephalography can be more than halved when using the two shielding devices ACC and CTP. The shielding of the radiosensitive thyroid gland contributes largely to this reduction. The use of CTP and ACC can reduce the collective dose in a predominantly young population, thereby reducing risks to public health.

Conflict of interest

The first author has a financial interest in the company GentleCeph Ltd that is developing devices to reduce doses in cephalometric radiography. GentleCeph is making the ACC available to the profession and strives to do so with the CTP.

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