Are children’s dental panoramic tomographs and lateral cephalometric radiographs sufficiently optimized?

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Summary

Objectives: Children are especially vulnerable to harmful effects of ionizing radiation. Cutting down the dimensions of the X-ray beam is the most effective way to reduce the patient dose. We evaluated the appropriateness of field-size in the most frequent radiographs, dental panoramic tomographs (DPTs) and lateral cephalometric radiographs (LCRs) among 7- to 12-year-olds.

Materials and methods: The image field-size of 241 DPTs and 118 LCRs was analysed. The image field was considered appropriate when it did not include anatomic structures beyond the area of clinical interest. The image field was compared with factors such as the age of the patient, the radiographic equipment used and the programme selected. Moreover, we assessed the use of thyroid shield in LCR.

Results: The field-size was too large in 70% of the DPTs horizontally and in 96% vertically. None of the DPTs were segmented. Every LCR showed appropriate limitation anteriorly, but the image field was too large in 54% posteriorly, in 86% superiorly, and in 76% inferiorly. A thyroid shield had been used in only 71% of cases.

Conclusion: Most DPTs and LCRs had been performed sub-optimally. An abundance of DPTs had been taken using an adult programme, and the field-size had not been sufficiently adjusted in LCRs, possibly for technical reasons. To facilitate adherence to radiological best practice the equipment used for DPTs and LCRs should facilitate the adjustment of field-size in both the vertical and horizontal planes. In addition, those involved in taking radiographs should maintain their skills through regular update courses.

Introduction

Optimization forms one of the three fundamental and universally accepted principles of radiation protection. It means that the radiation dose should be kept as low as reasonably achievable (‘ALARA’) while still being adequate for diagnostic image quality. Effective dose is a dose quantity that represents the probability of stochastic health risk, cancer or genetic effects, of ionizing radiation. It takes into account not only the absorbed energy, but also the specific radiosensitivity of the different organs situated in the irradiated field. The organ-specific sensitivity is expressed by tissue weighting factor (1).

Radiographic examinations can be optimized by adjustment of image field-size, exposure parameters, and filtration, and by use of protective lead aprons (2). Lead shields are used to protect particularly sensitive organs such as the thyroid gland. Its irradiation leads to an increased risk of hypothyroidism, thyroid nodules, and...
thyroid cancer, particularly in children (3). Irradiation of the eyes even at low doses results in an elevated risk of cataract formation (4). Tissue weighting factors have been given for these sensitive areas of the body. In 2007, tissue weighting factors were also introduced for the brain, salivary glands, and the oral mucosa. This highlights the risk posed to the individual due to routine intra-oral and extra-oral radiographic examination (1, 5). Dental radiography has been indicated as a risk factor for cancer of salivary gland and even for intracranial tumours (6, 7). It is believed that children are at particular risk from these unintended effects of radiographic examination due to their increased rate of cellular division and by having a long remaining lifespan. This has rightly placed them under special protection in radiation protection legislation (1, 2).

During dental panoramic tomography, the X-ray beam passes through salivary glands, oral mucosa, and part of orbits (8). The thyroid gland may also become partly exposed if the beam area is not restricted to the level of inferior mandibular border. During lateral cephalometric radiography, the whole brain and cervical spine may become irradiated, depending on the size of the X-ray beam (2), and exposure of salivary glands and oral mucosa cannot be avoided. The thyroid gland is also located within the primary X-ray beam if more than four upper-most vertebrae are included in the field (9).

In 2008, 25% of 7- to 12-year-old Finnish children underwent conventional radiographic examination (other than intra-oral dental radiography). Of all conventional radiographs 27% were dental panoramic tomographs (DPTs) and 16% were lateral cephalometric radiographs (LCRs) (10). These examinations were less frequent in both younger and older age groups. All LCRs, and as many as 95% of DPTs are taken for orthodontic reasons (11). Since these examinations are frequently undertaken among the paediatric population who are at an increased risk of developing potential unwanted effects, the aim of our study was to assess how LCRs and DPTs are optimized. We were interested in finding out how the image-field was focused to the region of interest, if this was associated with the radiographic equipment and programme used, if segmented DPTs had been taken, and if a thyroid shield had been used in LCR.

**Materials and methods**

**Radiographic material**

Our study was conducted retrospectively on a randomized sample, comprising 241 DPTs and 118 LCRs of 7- to 12-year-old children, who were treated in the Oral Healthcare Department of the City of Helsinki. Permission for conducting the study was obtained from the Oral Healthcare Department of City of Helsinki, Finland. The material and randomization of the patients have been described earlier (11). From the radiographs we analysed: 1. age of the patient, 2. type of panoramic or cephalometric device, 3. type of DPT programme (adult/child/segmented), 4. appropriateness of the irradiated field-size, and 5. use of thyroid shield.

**Definition of an optimum field size in DPT (Gold Standard)**

Based on the rule that the X-ray beam must not be larger than the area of clinical interest (12), we formulated the appropriate field-size for a DPT as follows: it provides an image of the entire maxillary-mandibular region, including the dentition, whole mandible and maxilla with its tuberosity area, and floor of the maxillary sinuses (13). Hence, the field of image should be optimized horizontally so that condylar processes are the most lateral structures that must be imaged completely (14). Due to the technique of DPT and the angulation of the X-ray beam in the region of the temporomandibular joint, the external auditory meatus (EAM) always projects on the lateral side of the condylar process (15). According to our criterion, the horizontal limitation of the field was appropriate when the condylar processes were completely visible but lateral to them, not more than the medial-lateral width of the EAM.

Vertically, the area above the orbital rim is not of dentist’s interest, and exposure of the eyes should be avoided (16). In order to secure a view of the cranial part of the condylar head, however, it is necessary to accept inclusion of the inferior part of the orbits. In our criteria, the superior limitation of the field was appropriate when the condyles were included but nothing above the maximum medial-lateral width of the orbit. Inferiorly, the area should not contain anything below the inferior border of the mandible, to avoid unnecessary exposure of the thyroid gland (17). We accepted a limit slightly below the level of the bony mandible as it might represent soft tissue of chin (Figure 1).

**Definition of an optimum field-size in LCR**

In LCR, the area of clinical interest is usually smaller than the imaged area (2). Visualization of the entire head and the whole cervical spine is not necessary for cephalometric analysis, and structures: 1. superior to the orbital rim and skull base, comprising the superior part of the brain and calvaria, 2. posterior to the occipital condyles, and 3. inferior to the hyoid bone can be excluded from the imaged area (12). Anteriorly, the soft tissue profile including the tip of the nose must be in the image-field to facilitate soft tissue profile analysis. Related cephalometric points and analyses have been summarized for instance by Jacobson and Vlachos (18). Posteriorly, inclusion of the vertebral corpora in the sagittal direction facilitate evaluation of the maturity of the vertebral spine (19), and view of the spinous processes at least partially makes it possible to detect gross abnormality in the anatomy of the craniovertebral junction (20) or of the vertebrae themselves (21). A view of the structures posterior to spinous processes and foramen magnum is not essential for routine orthodontic diagnostics and should only for specific indications be included in the irradiated field.

The same applies to superior parts of the cranium. According to our criteria, superior extension of the field 5 cm cranial from the sella turcica is acceptable and ensures visualization of the skull base that contains structures pertinent for cephalometric analysis and superimposition (22), as well as the most prominent part of the frontal bone, the hard tissue glabella (23). Inferiorly, the inferior contour
of the mandibular soft tissue and the hyoid bone must be visible to facilitate for instance diagnostics of patients with sleep-disturbed breathing (24). Of the cervical spine, not more than four uppermost vertebrae should be completely included in the radiated field in cranial-caudal direction. This is enough to estimate the timing of growth spurt by maturational stage of the cervical vertebrae, if wanted (19). Structures below must be covered with a thyroid shield (Figure 2).

**Statistical analysis**

Logistic regression analysis using R language (25) was used to determine the association between: 1. age and appropriateness (no/yes) of image field in different planes of DPTs and LCRs, 2. device and appropriateness of the field-size in DPTs, as well as 3. programme and appropriateness of the field-size in DPTs. Association was tested using likelihood ratios test.

**Results**

**Type of DPT device and DPT programme**

The DPTs had been taken with five types of devices: Orthopantomograph OP® 200 D (Instrumentarium Dental, Finland), Cranex® D and Cranex Excel Ceph® (Soredex Dental Malaysia, Finland), Orthophos XG5® (Sirona Dental System, Germany), and Planmeca Proline® XC (Planmeca, Finland). All five devices offer a separate child programme (Table 1). Yet, of the 241 DPTs, as many as 187 (78%) had been taken using the adult programme. All children imaged with Orthophos XG5® and all but one of them imaged with Cranex D® had been exposed using the adult programme. The child programme had been chosen in 69% of exposures with Orthopantomograph OP® 200 D, and in 47% in question of Cranex Excel Ceph®. Both images taken with Planmeca Proline® XC had been taken using the child programme.

It turned out that the choice between the two programmes was not associated with the age of the patient (P = 0.35; Figure 3). All five devices also served possibilities to take segmented DPTs, but these had not been obtained at all.

**Field size in DPTs**

In the horizontal plane, 68 (30%) of the total 241 DPTs showed appropriate field-size. The image-field was too wide at least unilaterally in as many as 169 DPTs (70%) (95% confidence interval (CI) 65–76%). In only three DPTs the image-field appeared too narrow with partial, unilateral cropping of condylar process, but in two of them this resulted from asymmetric positioning of the patient. In one DPT the appropriateness of the horizontal limitation remained unclear because the EAMs were completely cropped in the vertical plane. Correlation between the status of the horizontal field-size and type of device and programme used (child/adult) was analyzed in 236 DPTs, excluding the rare ones with too small or unclear field-size or imaged with Planmeca Proline (Figure 4). In logistic regression model with only device as explanatory variable, device was significantly associated with appropriateness of the field-size in horizontal plane (P < 0.0001). The probability of appropriateness of the field-size in horizontal plane was also significantly associated with programme used, in advantage of the child programme (P < 0.0001). Odds ratio (OR) for adult programme compared to child programme was 0.002 (95% CI 0.0003–0.01805). Table 2 demonstrates pairwise comparisons of devices in relation to probability of appropriateness of the field-size in horizontal plane.

In the vertical plane, of the total 241 DPTs, 156 (65%) (95% CI 58–70%) displayed an image-field that was too extended both superiorly and inferiorly at the same time. Only eleven DPTs (4%) (95% CI 2–8%), taken of children with the average age of 11, had appropriate field-size both superiorly and inferiorly at the same time. In rest of the DPTs (31%), the image-field was too large either superiorly or inferiorly. Correlation between the status of the vertical

![Figure 2](https://example.com/image2.png)

**Figure 2.** Graph of a lateral cephalometric radiograph showing appropriate field-size in horizontal and vertical planes.

![Table 1](https://example.com/table1.png)

**Table 1.** Field-size of child/adult programme offered by different devices for dental panoramic tomography.

<table>
<thead>
<tr>
<th>Type of device</th>
<th>Field-size [width (cm) × height (cm)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopantomograph OP® 200 D</td>
<td>12×26</td>
</tr>
<tr>
<td>Cranex® D</td>
<td>15×24</td>
</tr>
<tr>
<td>Cranex Excel Ceph®</td>
<td>15×23</td>
</tr>
<tr>
<td>Orthophos XG5®</td>
<td>8×18</td>
</tr>
<tr>
<td>Planmeca Proline® XC</td>
<td>12×24</td>
</tr>
</tbody>
</table>

![Figure 3](https://example.com/image3.png)

**Figure 3.** Choice of programme for dental panoramic radiography (DPT) by patient age.
Field size and type of device and programme used was analyzed in 239 DPTs, excluding the two that had been imaged with Planmeca Proline (Figure 5). The appropriateness of the field-size in the vertical plane was associated with the type of device (P = 0.0041), but was not associated with the type of programme (child/adult) used (P = 0.65).

Out of a total of 241 DPTs, an optimum field-size was obtained in all directions in only three (1%) DPTs (95% CI 0.2–3.6%), whereas 109 patients (45%) (95% CI 39–52%), had been imaged with too large a field-size in all directions.

Analysis of association between the status of the field-size and the age of the patient revealed that the appropriateness of the field-size horizontally (P = 0.2588) or inferiorly (P = 0.3932) were not associated with the age of the patient (Table 3). Age however, did play a significant role in the appropriateness of field-size superiorly (P = 0.01396). DPTs taken from 12-year-olds displayed more frequently appropriate height than the ones taken of 7-year-olds (OR 8.76; 95% CI 2–11%). The result of the other age groups did not differ from those found in the 7-year-olds.

Field size in LCRs and the use of thyroid shield
All the 118 LCRs showed appropriate field limitation anteriorly, showing the soft tissue profile in full. Posteriorly, the image-field had been limited appropriately in 54 radiographs (46%) (95% CI 36–55%). Sixteen LCRs (14%) (95% CI 7–21%) displayed appropriate field-size superiorly, and 28 (24%) (95% CI 16–32%) inferi orly. Eight children (7%) (95% CI 3–13%) had appropriate field-size in both directions of the vertical plane. As a result, seven LCRs (6%) (95% CI 2–11%) fulfilled all criteria of optimum field-size, whereas in 48 (41%) (95% CI 32–50%) the image-field extended too far posteriorly, superiorly, and inferiorly at the same time. Statistically, there was no association between the appropriateness of the field-size posteriorly (P = 0.7741) and superiorly (P = 0.33761) and the age of the child. There was a slight association between appropriateness of the field-size inferiorly and the age of the patient (P = 0.04078) (Table 4).

The corpora of four cranial vertebrae were completely seen in cranial-caudal direction in 28 LCRs (24%) (95% CI 16–32%). Most of the LCRs (57%) displayed more than four cranial vertebrae, and 19% of them displayed less than four. A thyroid shield had been used in 84 children (71%) (95% CI 62–79%). Among LCRs with thyroid shield, 26% (22/84) demonstrated less than four cranial vertebrae, 33% (28/84) four cranial vertebrae, and 40% (34/84) more than four cranial vertebrae. Hence, a desired result—four most cranial vertebrae visible in presence of thyroid shield had been obtained in 24% (28/118) (Figure 6).

Discussion
In the present study, we found out that only a small fraction of DPTs (1%) and LCRs (6%) fulfilled the criteria that we ourselves set for optimum limitation of the image-field. The criteria were formulated after careful consideration of the clinicians’ interests and leaving reasonable margins so that they would not be beyond technical possibilities to always achieve. The main motivational factor was the reduction of the dimensions of the irradiated field, resulting in a subsequent decrease in dose (26–28), contained to the area of interest, and thus effectively protecting the patient during extra-oral radiography. To our best knowledge there is no other study evaluating appropriateness of the image-field in relation to anatomical structures and area of clinical interest in DPTs and LCRs.

In our study, most of the DPTs (78%) had been taken with adult programme, although the patients were 7- to-12-year-old children. Type of programme (child/adult) was not chosen based on the age of the patient but rather based on the type of device in use, yielding a proportion of child DPTs ranging from 0% to 100%. Subsequently the majority of the DPTs (70%) were too extended laterally. About 96% displayed a field-size that was too large in the vertical direction, and this was also the case for those taken with the child programme. Age of the child was associated with the appropriateness of the field-size superiorly. Provided that the chin is properly positioned to the chin support, the vertical height of the patient’s face largely determines the exposure to the eyes. The face grows most in the vertical dimension (29), and also shows marked inter-individual variation in its relationship of dimensions with brachycephalic and dolicocephalic extremes.

Table 2. Pairwise comparison of devices in relation to appropriateness of field-size in horizontal plane (yes/no) of dental panoramic tomographs based on univariate logistic regression model. Odds ratios (with 95% confidence intervals).

<table>
<thead>
<tr>
<th>Type of devices</th>
<th>Odds ratio (2.5–97.5%)</th>
<th>Difference in probability of appropriateness of field-size in horizontal plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranex® D</td>
<td>Orthophos XG5®</td>
<td>1.75 (0.63–4.88)</td>
</tr>
<tr>
<td>Cranex® D</td>
<td>Orthopantomograph OP® 200 D</td>
<td>19.06 (4.92–73.79)</td>
</tr>
<tr>
<td>Cranex® D</td>
<td>Cranex Excel Ceph®</td>
<td>7.25 (2.79–18.83)</td>
</tr>
<tr>
<td>Orthophos XG5®</td>
<td>Orthopantomograph OP® 200 D</td>
<td>0.09 (0.02–0.3)</td>
</tr>
<tr>
<td>Orthophos XG5®</td>
<td>Cranex Excel Ceph®</td>
<td>0.24 (0.11–0.5)</td>
</tr>
<tr>
<td>Orthopantomograph OP® 200 D</td>
<td>Cranex Excel Ceph®</td>
<td>2.62 (0.83–8.26)</td>
</tr>
</tbody>
</table>
During a DPT the X-ray beam moves from its source toward the patient’s head in upward (6–8 degree) direction (8). Therefore, structures below the mandibular inferior border such as thyroid gland might easily become exposed if the irradiated area is not limited inferiorly to the patient’s chin. Since use of thyroid shield during DPT is not recommendable because of its interference with the primary X-ray beam (2), the only way to protect the radio-sensitive thyroid gland is by collimating the beam inferiorly and positioning the chin properly.

In Orthophos XG5® (Sirona Dental system, Germany), the DPT child programme excessively collimates the field both horizontally and vertically, sometimes leading to partial and unwanted cropping of condyles and un-erupted maxillary teeth (Figure 7). This, in turn, may necessitate a repeated exposure. Awareness of this excessive collimation may explain why none of the DPTs that had been taken with this device among the material of the present study had been taken using the child programme.

Almost all of the DPTs (95%) in this study had been performed for orthodontic reasons, and of those 19% had been taken for monitoring orthodontic treatment such as follow-up of canine eruption (11). In such examinations image field could be restricted to specific part of the jaws using segmented DPTs. Despite the fact that all devices appearing in this article offer this possibility, segmented images were non-existent. This is a flourishing example of how perhaps lack of knowledge and at least lack of communication between the referrer (orthodontist) and the operator who performs the exposure lead to non-ideal optimization.

In the LCR, international guidelines recommend reduction of the field-size and dose by utilizing modified wedge collimation to limit the beam to the area needed for cephalometric analysis (2, 30). In our material, only 6% of the LCRs fulfilled the recommendations. All devices used in this study were not, however, equipped with both horizontal and vertical collimators. Our results implied deficient collimation of LCRs more often superiorly than posteriorly. Indeed, some devices, such as Orthopantomograph OP® 200 D (Instrumentarium Dental, Finland), offer several alternatives for posterior limitation, but only one option for superior limitation of the field-size. Other devices may offer even less choice for collimation.

The investigation into the use of a thyroid shield in LCRs provided interesting findings. Although it had been used in 71% of 

### Table 3. Field limitation status in dental panoramic tomographs by patient age.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Field limitation status in the horizontal plane (n = 237)</th>
<th>Field limitation status in the vertical plane (n = 241)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Too large (n = 6)</td>
<td>Too large (n = 6)</td>
</tr>
<tr>
<td>8</td>
<td>owan (n = 6)</td>
<td>owan (n = 6)</td>
</tr>
<tr>
<td>9</td>
<td>owan (n = 6)</td>
<td>owan (n = 6)</td>
</tr>
<tr>
<td>10</td>
<td>owan (n = 6)</td>
<td>owan (n = 6)</td>
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<tr>
<td>11</td>
<td>owan (n = 6)</td>
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</tr>
<tr>
<td>12</td>
<td>owan (n = 6)</td>
<td>owan (n = 6)</td>
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</table>

### Figure 5. Status of field-size in vertical plane in 239 dental panoramic tomographs (DPTs) by type of device and programme (child DPT or adult DPT).
cases, only a quarter of radiographs showed the desired view of the spine. The majority displayed more than four cranial vertebrae, and in some instances even the sixth cranial vertebra (C6) was visible. This indicated that the thyroid shield, whilst used, had been positioned too low and the thyroid gland had been inadequately protected. In the study of Hujoel et al. (31), in the presence of thyroid shield the most cranial vertebra visible on LCR was C3 or C4, and in the absence of the shield, C5. In our study, placement of the thyroid shield was more variable, possibly because the radiographs had been taken by different dental nurses with different skills. This is clearly an area that demands continuing education.

The lack of the thyroid shield in almost one-third of our patients can be explained by the uncertainty of dental nurses in placing the shield at a proper level and fear of excessive coverage of vertebrae during LCR, thus hampering the evaluation of the skeletal maturity (19). In line with that fear it has been reported that use of thyroid shield leads to coverage of the hyoid bone as well as C2 and C3, and the use of the shield during LCR has been recommended only when information on skeletal maturity is not necessary (32), or when the most inferior structure needed for cephalometric analysis is C1 (33). Our study in contrast to those previous studies has shown that despite the use of a thyroid shield, visualization of the four uppermost cervical vertebrae is still possible.

Analysis of anatomic structures visible in the present radiographs showed that in some DPTs, the image-field even included frontal sinuses, large neural-cranial area above skull base, as well as up to six cranial vertebrae with their spinous processes completely, which indicates that sensitive organs such as brain, eyes, as well as thyroid gland had become irradiated. These structures are located far away from the area required for diagnosis and their irradiation only increases the effective dose to the child.

Similarly, some LCRs comprised the whole cranium and up to seven cervical vertebrae. Leaving part of the neurocranium and cervical vertebrae out of the irradiated area in LCR by modified wedge collimation has been shown to lead to a 55% reduction of field-size and consequently result in a 47% reduction in effective dose (34). An effort has been made to reduce the irradiated area and effective dose of orthodontic patients during LCR by shielding part of the skull—an area not required for cephalometric analysis—by attaching an anatomical cranial collimator (ACC) to the cephalostat, and using a cephalographic thyroid protector (CTP) (35,36). Application of ACC only has resulted in a 27–35% reduction of the irradiated area without significant interference with cephalometric landmarks.
This can be increased to a reduction of the effective dose by 59% if both ACC and CTP are applied simultaneously (36).

Inclusion of the whole head in LCR has sometimes been motivated by incidental findings. Most of the incidental findings in pre-treatment LCRs and dental radiographs are, however, non-pathologic anomalies or normal variants that do not require further investigations (38). Putting the ‘ALARA’ principle fully into practice means that the optimum field size is not fixed but greatly depends on the patient and indication for imaging, thus ranging from the whole head in some syndromic patients to a strictly limited view that would yield the necessary information, such as inclination of the incisors in a follow-up cephalogram. Therefore, the devices should be designed to easily allow collimation of the exposed area both vertically and horizontally at both ends, similar to those used for radiographic examination of the extremities.

Most LCRs are taken for standard cephalometrics. The optimum field size even for this purpose is not, however, fixed; facial dimensions and proportions vary from child to child even within the same age group, and they are inevitably influenced by growth. For the purposes of the present study we analysed, using the data of Helsinki Longitudinal Growth Study, how much the average growth merely from age 7 to 12 would affect the optimum field-size in LCR. Using our own definition for optimum limitation horizontally, we chose to measure the distance from the soft tissue tip of the nose (Pronasale) to the posterior margin of the foramen magnum (Opisthion). The average increase of this nearly horizontal measure from 7 to 12 was 6 mm. From 7 to 12 years the vertical change in facial size, measured as distance between Glabella and Menton, was in average 10 mm (Marjut Evälahti, personal communication). At these young ages facial growth in the horizontal plane turned out to be greater than in the vertical plane, especially when changes in the soft tissue nasal profile were taken into account.

All and all, individual optimization of field size in DPT and LCR would be beneficial in terms of dose reduction. Yet, it puts high requirement on patient positioning, since any errors would potentially result in an image that might not be diagnostically acceptable, whereas images with a large field-size provide an allowance for slight positioning errors. Our criteria for acceptable field size were therefore set at a level that would be reasonable to achieve through a combination of educating members of the dental team and effective engagement with the manufacturers of machines used in extra-oral dental radiography. The next generation of DPT and LCR machines should be capable of recording vertical and lateral dimensions of the face prior to exposure, to allow effective targeting of the field-size. This will enable the clinician to fully optimize each exposure for each patient.

Conclusions

Our study shows that in DPTs and LCRs taken from 7- to-12-year-old children, the X-ray beam frequently covers an area that is much larger than the area of interest, inadvertently exposing other structures of the maxillofacial, cranial, and neck region. Some of these structures are particularly sensitive to radiation such as the brain, eyes, and thyroid gland. Factors that have been identified in the incorrect tailoring of the field-size of the exposure to the area of interest include: 1. Use of the adult programme setting on child patients, 2. not using the segmental capability that most DPT machines possess, 3. staff knowledge with regards to correct thyroid shield use, and 4. limited possibilities to collimate the beam in LCR.

It is therefore recommended that the design of DPT and LCR devices should include the capability of different collimation settings that can be easily adjusted during the dental radiography process. In addition there should be regular staff education and demonstration on the use of thyroid shields and the available programmes/setting of the department DPT and LCR devices.

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References


