Original article

Quality assessment of orthodontic radiography in children

Elmira Pakbaznejad Esmaeili*.*, Marja Ekholm*.*, Jari Haukka**** and Janna Waltimo-Sirén***.

*Oral Radiology, Department of Oral and Maxillofacial Diseases, University of Helsinki, **Oral Healthcare Department of City of Helsinki, ***University Dental Clinic of City of Helsinki, ****Department of Public Health, University of Helsinki, *****Orthodontics, Department of Oral and Maxillofacial Diseases, University of Helsinki, Finland

Correspondence to: Elmira Pakbaznejad Esmaeili, Department of Oral and Maxillofacial Diseases, PO Box 41, University of Helsinki, FI-00014, Finland. E-mail: elmira.pakbaznejad@helsinki.fi

Summary

Objectives: Numbers of dental panoramic tomographs (DPTs) and lateral cephalometric radiographs (LCRs) outweigh other radiographic examinations in 7- to 12-year-old Finns. Orthodontists and general practitioners (GPs) involved in orthodontics hold therefore the highest responsibility of the exposure of children to ionising radiation with its risks. Against this background, lack of reports on the quality of orthodontic radiography is surprising. The purpose of our study was to shed some light and draw the awareness of the orthodontic community on the subject by analyzing the quality of orthodontic radiography in Oral Healthcare Department of City of Helsinki, in the capital of Finland.

Materials and methods: We analyzed randomly selected 241 patient files with DPTs and 118 patient files with LCRs of 7- to 12-year-olds for the indications of radiography, quality of referrals, status of interpretation, and number of failed radiographs.

Results: The majority of DPTs (95%) and all LCRs had been ordered for orthodontic reasons. Of the DPTs, 60% were ordered by GPs, and of the LCRs, 64% by orthodontists. The referrals were adequate for most DPTs (78%) and LCRs (73%), orthodontists being responsible for the majority of inadequate referrals. Of the DPTs, 80% had been interpreted. Of the LCRs, 65% lacked interpretation, but 67% had been analysed cephalometrically. Failed radiographs, leading to repeated exposure, were found in 2–3%.

Conclusion: The quality assessment revealed that orthodontic radiography may not completely fulfill the criteria of good practice. Our results stress further need of continuing education in radiation protection among both orthodontists and GPs involved in orthodontics.

Introduction

The standpoint of quality assessment in radiological practice is the fulfillment of the universally applied principle of justification. Justification as the first fundamental principle in radiation protection means that the net positive benefits of using ionizing radiation must outweigh the potential disadvantages (1). Hence, radiography is justified only when clinical examination supplemented with other examination methods is not enough for diagnosis, treatment planning, monitoring treatment result and follow-up studies (2). Furthermore, justification and the referral process are included in generic criteria of good practice, which is recommended based on the scientific evidence-based data, national or international standards, guidelines, recommendations, and legal requirements (3).

For the radiologist and radiographer, in order to justify a radiographic examination, evaluate its necessity, and take the responsibility for an exposure, the referring dentist should provide all necessary clinical information (2, 4). This emphasizes the importance of
appropriateness and quality of a referral as the basis of the justification and referral criteria (3, 4). After taking a radiograph, all radiographic data must be systematically analysed and reported in order to obtain maximum benefit from it (4). Proper analysis, complete interpretation and report of a radiographic examination contribute to the diagnostics by connecting radiological findings to the patient’s clinical findings (5). This in turn promotes the implementation of good practice.

Good practice is essential in orthodontic radiography. Yet, in Finland, for instance, national guidelines for ordering orthodontic radiography are lacking, although the total numbers of dental panoramic tomographs (DPTs) and lateral cephalometric radiographs (LCRs) among 7- to 12-year-old children (in a population of 5 million) in 2008 were 23,862 and 14,033, respectively (6). DPT was the most frequent and LCR the second most frequent conventional radiographic examination among 7- to 12-year-olds, counting for 27% and 16% of all the traditional radiographic examinations, intra-oral radiography excluded (Figure 1) (6). In a younger age group (2- to 6-year-olds), DPT counted for 8% of radiological examinations, whereas LCR was not taken in any (6). In an older age group (13- to 16-year-olds), DPT counted for 13% and LCR for 6% of all conventional radiographic examinations in 2008 (6). Good practice in orthodontic radiography has been promoted for instance by the British Orthodontic Society and published under the title Orthodontic Radiographs (7). To our best knowledge, there is no publication showing how well those instructions have been applied. The aims of our study were 1. to find out the indications of DPTs and LCRs, taken recently of Finnish children aged 7–12 years, 2. to investigate the quality of referrals of these radiographs, 3. to find out the proportion of unacceptable or failed radiographs in this peak age group. Thereby, we wanted to evaluate the quality of the radiographic practice in order to identify possible areas of improvement and map the necessity of further education of dental professionals.

Materials and methods

Based on the population numbers, the nationwide records of the numbers of DPTs, and the knowledge that the vast majority of any dental care for growing patients in Finland is given at the public sector, we estimated that 10% of DPTs taken during 1 year of 7- to 12-year-olds at Oral Healthcare Department of City of Helsinki, Finland, would make approximately 250 DPTs, sufficient for the present study. The patient selection was designed accordingly so as to yield a randomized, representative sample of children born within 1997–2003 of whom either a DPT or LCR or both had been taken in 2010. The basis of randomization was the date of exposure, being the 5th, 15th, or 25th day of each month. The initial randomisation yielded a list of 394 patients, which was more than the desired size of the sample. We therefore picked every other patient and then consecutive patients from the start of the original list of 394 until the number of patients equaled 250. We searched their files from the electric patient information system Effica® (Tieto, Helsinki, Finland) that covers all dental care information of patients treated in the public Oral Healthcare Department of City of Helsinki. The DPTs and LCRs of the patients were viewed from Digora® for Windows 2.5 software (Soredex Dental Malaysia, Helsinki, Finland). The study was conducted under the permission of Oral Healthcare Department of City of Helsinki, Finland.

It turned out that out of the 250 children, 241 (96%) had undergone DPT, and 118 (47%) LCR. DPT as a sole examination had been performed in 132 (53%) and LCR in 9 (3%). In 109 cases (44%) both DPT and LCR had been taken, but not necessarily on the same day. All data were analysed during a 5-month period by a dentist completing her specialist training in oral radiology (EPE), and points to any uncertainty were re-analysed together with a senior oral radiologist (ME) and a senior orthodontist (JWS).

The following information was analysed and registered anonymously:

1. Age of the patient at the moment of radiography.
2. Indication for the radiography; If not apparent based on the referral text, the indication for radiography was decided based on all available information registered in the patient file and the stage of treatment.
3. Adequacy of referral for radiography; The referral was considered adequate when an indication for the radiographic examination was given.
4. Educational status of the referring dentist; Orthodontist or general practitioner (GP).
5. Quality and extent of the interpretation of the radiographic data; A systematic analysis of the image, regardless of the indication of radiography, was considered as a complete interpretation. An interpretation only covering the findings related to the indication of radiography without reporting other significant observations was considered as a brief interpretation.
6. Cephalometric analysis of the LCRs; Accepted even if it was very limited, such as assessment of the facial growth pattern.
7. Repeated exposure; The number and the type of radiographs taken on the same day with the subject DPTs and LCRs.
8. Exposure history of the patients; The number and the type of dental radiographs taken earlier than the subject DPTs.

![Figure 1. Distribution of traditional radiographic examinations among 7- to 12-year-olds in 2008 in Finland. Based on ref. (6). Intra-oral radiographs are not included in these statistics.](https://academic.oup.com/ejo/article-abstract/38/1/96/2599927)
Statistical analysis

The numeric difference of the radiographs between the age groups was evaluated by comparing the number of DPTs of each age group with the population size of the corresponding age group in Helsinki. As a reference group we used the 7-year-olds [odds ratio (OR) = 1]. Logistic regression analysis using R language (version 2.13.0; R Development Core Team, R: A Language and Environment for Statistical Computing, Vienna, Austria, 2008) was used to determine the association between age and the proportion of the DPTs. Chi Square test using R language was performed to assess the significance of difference between reasons of ordering the DPTs and significance of difference between subgroups of orthodontic reasons.

Probability of adequate referral was modeled with logistic regression using type of X-ray and education of referring dentist as explanatory variables. Probability of complete (complete versus brief or non-existing) interpretation of DPT, and interpretation and cephalometric analysis of LCR was modeled with logistic regression using education of the referring dentist as explanatory variable.

Results

Age distribution

Our material covered the ages from 7 to 12 years. Logistic regression analysis showed that the proportion of DPTs was significantly associated with age. The 12-year-olds had a lower probability of having had DPT taken than the 7-year-olds (OR 0.50; 95% CI 0.29–0.83). Similarly, the number of DPTs in 12-year-olds was significantly lower than in ages 9–11 (Table 1).

It appeared that the LCRs were more evenly distributed in the age groups 7–12 years than the DPTs, and statistically there was no difference between different age groups (Table 1).

Indications for radiography

Of the 241 DPTs, 229 (95%) had been ordered for orthodontic reasons and only nine (4%) for other reasons, including overall assessment of the dentition, detection of caries, evaluation of trauma or infection, postoperative assessment, as well as pain in the temporomandibular joint. In case of three DPTs (1%), the indication for radiography was not given and could not even be assessed indirectly from the information registered in the patient file. Of the 229 DPTs taken for orthodontic reasons, two had been taken for both orthodontic reasons and overall assessment of the dentition, and one for both orthodontic reason and assessment of caries. Orthodontic reasons were statistically significantly the most common ones for ordering DPT in these 7- to 12-year-olds (P < 0.0001).

Further analysis of the 229 DPTs performed for orthodontic reasons revealed that 141 of them (62%) were ordered for orthodontic patient selection, initial assessment and consultation for the need of orthodontic therapy or observation of the development of the dentition, 43 (19%) for the initiation of orthodontic therapy, 43 (19%) for monitoring the treatment, and 2 (1%) for assessment of the final treatment result (Table 2). The difference between the subgroups of orthodontic reasons was statistically significant regardless of the age (P < 0.0001), but this significance decreased with increasing age of the patients (P = 0.045).

All the 118 LCRs had been ordered for orthodontic reasons. Of them, 51 (43%) had been ordered for orthodontic patient selection,

Table 1. Age distribution of the random sample of DPTs and LCRs taken of 7- to 12-year-olds and probability of radiography by age group. OR with 95% confidence interval are based on logistic regression model. The population size of age groups was obtained from statistical databases of Statistics Finland (www.tilastokeskus.fi).

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Number of radiographs</th>
<th>Population size in Helsinki in 2010</th>
<th>OR</th>
<th>DPT</th>
<th>LCR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPT (n = 241)</td>
<td>LCR (n = 118)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>41 (17%)</td>
<td>18 (15%)</td>
<td>4835</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>35 (15%)</td>
<td>20 (17%)</td>
<td>4771</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>50 (21%)</td>
<td>22 (19%)</td>
<td>4927</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>48 (20%)</td>
<td>20 (17%)</td>
<td>4842</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>45 (19%)</td>
<td>25 (21%)</td>
<td>4880</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>22 (9%)</td>
<td>13 (14%)</td>
<td>5155</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DPT, dental panoramic tomograph; LCR, lateral cephalometric radiograph; OR, odds ratio.

Table 2. Division of the 229 DPTs ordered for orthodontic reasons and the 118 LCRs by the type of orthodontic indication and age of the patient.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Patient selection, initial assessment, and consulting. In DPT: observation of the development of dentition</th>
<th>Initiation of treatment</th>
<th>Monitoring of treatment</th>
<th>Final assessment of treatment result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPT</td>
<td>LCR</td>
<td>DPT</td>
<td>LCR</td>
</tr>
<tr>
<td>7</td>
<td>24</td>
<td>8</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>21</td>
<td>10</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>32</td>
<td>11</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>31</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>25</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

DPT, dental panoramic tomograph; LCR, lateral cephalometric radiograph.
initial assessment and consultation for the need of orthodontic therapy, 48 (41%) for the initiation of orthodontic therapy, 18 (15%) for monitoring the treatment, and 1 (1%) for assessment of the final treatment result (Table 2). The difference between the subgroups of orthodontic reasons was statistically significant ($P < 0.001$).

**Educational status of the referring dentist and the quality of referrals**

Of the total 241 DPTs, 60% were ordered by GPs, and the rest of them (40%) by orthodontists. This proportion remained almost the same (59% versus 41%) in the 229 DPTs ordered for orthodontic reasons. Of the nine DPTs ordered for non-orthodontic reasons, four had been ordered by orthodontists and five by GPs. All three DPTs without indication had been ordered by GPs. Covering all 241 DPTs, the referrals were considered adequate in 188 (78%) cases (95% CI 0.72–0.83).

Of the total 118 LCRs, 76 (64%) were ordered by orthodontists and the rest of them by GPs. The referrals to LCR were considered adequate in 86 (73%) cases (95% CI 0.63–0.80).

The education of the referring dentist was associated with the type of ordered radiographic examination; The proportion of LCRs of ordered radiographs was higher among orthodontists than GPs (OR 2.68; 95% CI 1.70–4.24). There was no association between the type of radiographic examination (whether DPT or LCR) and the quality of referrals. It turned out, however, that odds of adequate referral for DPT and LCR was significantly lower for orthodontists compared to GPs ($P = 0.002$; Table 3).

**Interpretation of radiographs and cephalometric analysis of LCRs**

Of the 241 DPTs, 174 (72%) had been interpreted completely, 20 (8%) had been interpreted briefly, whereas 47 (20%) had not been interpreted at all (95% CI 14–25%). Education of the referring dentist was not associated with the status of interpretation of DPTs (OR 1.29; 95% CI 0.72–2.32; Table 4). Of the 118 LCRs, as few as 41 (35%) had been interpreted adequately (95% CI 0.26–0.44), while 79 (67%) had been analysed cephalometrically (95% CI 57–75%), according to written information in patient files (Table 5). Thirty-nine patients (33%) (95% CI 25–42%) did not have any results of cephalometric analysis in their files, and 37 (31%; 95% CI 23–41%) lacked both interpretation and cephalometric analysis of the LCR. Education of the referring dentist was associated with the status of interpretation and cephalometric analysis of LCRs. It turned out that LCRs ordered by orthodontists were more frequently interpreted (OR 3.26; 95% CI 1.33–7.93) and more frequently analysed cephalometrically (OR 3.22; 95% CI 1.44–7.19) than to those ordered by GPs.

**Unacceptable/failed radiographs**

Of the 241 patients with subject DPTs, six (2%), with the average age of 10 years, had a repeated DPT on the same day because of a positioning error or movement during radiography. Of the 118 patients with subject LCRs, four (3%), with the average age of 10.5 years, had a repeated LCR on the same day because of an error in head positioning. These numbers are clearly below the accepted 10% maximum level of unacceptable radiographs (4).

**Previous radiographs**

The type and number of earlier dental radiographs are given in Table 6. Notably only those that were taken in digital form could be taken into account. Twenty-three patients (9%) with earlier
Table 4. Status of the interpretation of 241 DPTs ordered by orthodontists and general practitioners.

<table>
<thead>
<tr>
<th>DPT ordered by</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete, n = 174 (72%)</td>
</tr>
<tr>
<td>Orthodontists, n = 97 (40%)</td>
<td>73</td>
</tr>
<tr>
<td>General practitioners, n = 144 (60%)</td>
<td>101</td>
</tr>
</tbody>
</table>

DPT, dental panoramic tomograph.

Table 5. Status of interpretation and cephalometric analysis of 118 LCRs ordered by orthodontists and general practitioners.

<table>
<thead>
<tr>
<th>LCR ordered by</th>
<th>Interpretation</th>
<th>Cephalometric analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes, n = 41 (35%)</td>
<td>No, n = 77 (65%)</td>
</tr>
<tr>
<td>Orthodontists, n = 76 (64%)</td>
<td>33</td>
<td>43</td>
</tr>
<tr>
<td>General practitioners, n = 42 (36%)</td>
<td>8</td>
<td>34</td>
</tr>
</tbody>
</table>

LCR, lateral cephalometric radiograph.

Table 6. Previous dental radiographs in digital form taken earlier than DPT in the 241 7- to 12-year-old patients and approximate exposed effective dose measured according to ref. (8).

<table>
<thead>
<tr>
<th>Age</th>
<th>DPT (n = 76)</th>
<th>LCR (n = 30)</th>
<th>Intra-oral (n = 96)</th>
<th>Individual cumulative effective dose (µSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>7</td>
<td>0–1</td>
<td>0.05</td>
<td>0–1</td>
<td>0.05</td>
</tr>
<tr>
<td>8</td>
<td>0–1</td>
<td>0.20</td>
<td>0–1</td>
<td>0.06</td>
</tr>
<tr>
<td>9</td>
<td>0–2</td>
<td>0.20</td>
<td>0–2</td>
<td>0.06</td>
</tr>
<tr>
<td>10</td>
<td>0–2</td>
<td>0.30</td>
<td>0–1</td>
<td>0.10</td>
</tr>
<tr>
<td>11</td>
<td>0–3</td>
<td>0.60</td>
<td>0–2</td>
<td>0.20</td>
</tr>
<tr>
<td>12</td>
<td>0–2</td>
<td>0.70</td>
<td>0–1</td>
<td>0.30</td>
</tr>
</tbody>
</table>

DPT, dental panoramic tomograph; LCR, lateral cephalometric radiograph.

Discussion

In the present study, we focused on different aspects of quality of orthodontic radiography, by analyzing a random sample of DPTs and LCRs taken of 7- to 12-year-olds. To our best knowledge, there is no other study showing the main indication of taking DPT and LCR in this age group, or analysing the quality of referrals and status of interpretation. We found remarkable deficiencies in the quality of both.

This study was carried out in the City of Helsinki, the largest city of Finland. Its population size was 583,350 in 2010, making approximately 11% of the whole population of the country, according to the Population Register Centre of Finland (http://vrk.fi). The oral health care department of City of Helsinki is the only public section that offers dental care, including orthodontic treatment, to its all citizens under 18 years of age, free of charge. Therefore, the department provides almost all of the dental care services offered to children. We can assume that our sample is representative for the population in Helsinki, and can, with some reservations, be generalized to whole Finland using inferential statistics. These reservations include factors such as regional differences in the orthodontic practices in the absence of strict national guidelines when it comes to instance to patient selection criteria.

The results of our study are important to the orthodontic community, since it became clear that not only every LCR but also the vast majority (95%) of the DPTs in 7- to 12-year-old children were ordered for orthodontic reasons. This can be considered as a good result, since DPT alone is not recommended for caries diagnostics (9). When it comes to the assessment of the quality of the radiographic practice, the results are less satisfying. Namely, we noticed that approximately one fourth of the DPTs and one fifth of the LCRs lacked an adequate referral. This might arise from lack of proper knowledge in regard to the role and importance of the referral process. An adequate referral is part of the radiographic selection criteria and must include adequate clinical information based on the signs, symptoms, and history of the patient, explaining the reason for exposure (4). Compared to GPs, orthodontists were more often responsible for inadequate referrals. LCRs, most of which were...
ordered by orthodontists, lacked an adequate referral more often than DPTs. This might be explained by the fact that the reason for radiography and its justification might be in itself clear for the orthodontists. Nevertheless, the person conducting the exposure, whether a radiographer or a dental nurse, and the radiologist also have the responsibility to authorize the exposure (10). This is possible only when an adequate referral is provided.

A very important issue related to the quality of practice and referral process is the timing of the radiographic examination. As a general rule, the radiography should be performed only after clinical examination and at a time point when its outcome is likely to affect the treatment decision within a short time frame (2). Here it turned out that the majority of the DPTs and slightly less than half of the LCRs were performed before onset of the actual treatment, predominantly for orthodontic patient selection. Moreover, most of the DPTs were ordered by GPs, while most of the LCRs were ordered by orthodontists. These are expected results as the primary imaging method for children with developing dentition and need of orthodontic treatment usually comprises a DPT, while LCR is often required for selected patients who need orthodontic treatment (4). The high number of GP-ordered DPTs could reflect a wish of the orthodontists that the patient already has a DPT at the time of patient selection in order to save another visit, even though it is not acceptable to refer patients to radiographs without a clinical indication because of logistic reasons (7).

A DPT might be required for selection of an orthodontic patient, for instance in the case of suspected hypodontia or ectopic eruption, but seldom an LCR (7). After individual consideration, an LCR is likewise recommended for diagnostics and treatment planning in the majority of cases, already chosen for orthodontic treatment, albeit some studies have shown that LCR does not have a significant effect on the treatment planning of orthodontic patients (11). In our random sample, only 45% of patients imaged with DPTs for orthodontic reasons also had LCRs, indicating that LCR had not been ordered routinely at the same time as the orthodontic patient. The Guidelines of Orthodontic Radiographs by British Orthodontic Society (7) and European Guidelines on Radiation Protection in Dental Radiology (4) offer simplified flow charts of whether a pre-treatment LCR is required.

Other timing points also became evident. Presumably the majority of the images that had already been taken here prior to the onset of the actual treatment had been useful for the initiation of the orthodontic treatment, since only a fifth of the DPTs, and slightly less than half of the LCRs were ordered for the initiation of orthodontic treatment, which is a understandable reason for radiography. As regards consecutive exposures, there are different opinions of the necessity to monitor the on-going treatment by the means of radiography. According to The Guidelines of Orthodontic Radiographs by British Orthodontic Society it might be necessary, but only after a proper clinical examination and only if obtaining the information from a radiograph is beneficial to the patient (7). Our results seem to be in line with those recommendations since only one fifth of the DPTs, and even fewer LCRs were taken for monitoring the orthodontic treatment. Similarly, the need of radiography at the end of the orthodontic treatment should be assessed individually, based on clinical indications. It may be relevant for example for patients with severe malocclusion and skeletal discrepancy, or at the end of treatment with functional appliances or fixed appliances (4, 7). In our material, radiographs ordered for the assessment of the treatment result were extremely few. Hence, radiography at the end of treatment was not performed routinely which is in line with the recommendations above.

One might assume that the proportion of radiographs taken for monitoring either the progression or final outcome of the orthodontic treatment had probably been higher if the study setting would have been extended to older age groups. Somewhat contradictory to that our study showed that orthodontic radiography was centered to the younger end of our random sample—as many as a third of the DPTs were ordered for 7- to 8-year-olds, and the number of children exposed at the age of 12 was statistically significantly lower compared to younger age groups. The early timing of DPT in our study hardly reflects a tendency to merely monitor the developing dentition, which is not routinely recommended (7, 12), but more likely a tendency to start orthodontic treatment relatively early in our country (13).

We were also interested in the total radiographic load of children. Of all children with DPT, this was the second DPT for the fourth of them, and 12% had undergone LCR. This is not surprising as most of the patients were imaged for orthodontic reasons. In another study, each patient who underwent at least one-year orthodontic treatment had three DPTs and three LCRs during the course of treatment, in addition to one full-mouth series of intra-oral radiographs (14). In our material the average number of previous radiographs, taken in digital form and for any indication, remained less than one DPT or LCR or intra-oral per patient. It was not possible to count the numbers of film radiographs, but they were probably few due to the shift to digital imaging since 2006.

The last critical step in the assessment of the quality of radiographic practice is the interpretation. Any radiograph must be interpreted completely, regardless of the reason of radiography (5), even if orthodontists may be interested in only part of the jaws or specific problems in dentition. Dental radiographs may be interpreted by the referring dentist or an oral radiologist, but the referring dentist is in principle responsible for the radiographs being interpreted. Our disappointing finding was that one fifth of the DPTs lacked interpretation of any depth, and of the LCRs two thirds lacked a complete interpretation, whereas one third had not been analysed even cephalometrically. The interpretation should cover all structures within the whole image. In question of LCRs this means that, in addition to an appropriate cephalometric analysis, all the imaged structures need to be interpreted properly for evidence of disease or injury (15). This evokes the question of the appropriate size of the image field: If the radiography is indicated for instance by need of cephalometric data for orthodontic treatment planning and there is no specific need to analyse the structure of the posterior cranium in a large image field, it ought to be reduced to only cover the actual area of interest, as recommended by the international guidelines (4).

GPs and orthodontist shared an equal responsibility for lacking interpretation of DPTs, whereas GPs were mainly responsible for the lack of interpretation and cephalometric analysis of LCRs. The orthodontists’ diagnostic needs as well as their higher professional skill had most probably led to the more frequent analysis and interpretation of LCRs. Nevertheless, our observation of the numerous DPTs and LCRs lacking any interpretation is likely to raise the question of their necessity for the management of the patient.

**Conclusion**

This retrospective assessment of the quality of extra-oral dental radiography indicated that within a random sample of 7- to 12-year-old patients in Oral Healthcare Department of Helsinki, Finland, all LCRs and 95% of the DPTs were ordered for orthodontic reasons. The radiographic practice was basically in line with the recommendations of international guidelines, such as Orthodontic Radiographs by British
Orthodontic Society (7), with low numbers of repeated exposures due to technical reasons or unjustified follow-up radiographs. There was, however, a clear need for improvement of the quality of orthodontic radiography, particularly regarding the adequacy of referrals and interpretation of the radiographs. We therefore identify a place for re-evaluation of the contents of the obligatory continuous professional education within radiation protection of both orthodontists and GPs involved in orthodontics, in order to maximize the benefit of the exposure for the best of children whose radiation protection is a special concern.

Funding
Finnish Women Dentists and Orthodontic Section of the Finnish Dental Society (to EPE).

References