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ORIGINAL ARTICLE

Type and location of findings in dental panoramic tomographs in 7–12-year-old orthodontic patients

Elmira Pakbaznejad Esmaeili[a,b], Marja Ekholm[a,c], Jari Haukka[d] and Janna Waltimo-Sirén[c,e]

[a]Oral Radiology, Department of Oral and Maxillofacial Diseases, University of Helsinki, Helsinki, Finland; [b]Oral Healthcare Department of City of Helsinki, Helsinki, Finland; [c]University Dental Clinic of City of Helsinki, Helsinki, Finland; [d]Department of Public Health, University of Helsinki, Helsinki, Finland; [e]Orthodontics, Department of Oral and Maxillofacial Diseases, University of Helsinki, Helsinki, Finland

ABSTRACT

Objective The Radiation and Nuclear Safety Authority in Finland has paid attention to the large numbers of dental panoramic tomographs (DPTs), particularly in 7–12-year-old children. The majority of these radiographs are taken for orthodontic reasons. Because of the high radiosensitivity of children, the size of the irradiated field should be carefully chosen to yield the necessary diagnostic information at the lowest possible dose. The purpose of the present study was, therefore, to assess the outcome of DPTs within this age group in terms of type and location of pathological findings. It was also hypothesized that DPTs of orthodontic patients rarely display unrestored caries. **Materials and methods** Four hundred and forty-one DPTs, taken of 7–12-year-old children in 2010–2014, were randomly sampled. The 413 of them (94%) that had been taken for orthodontic reasons were analysed. **Results** All pathologic findings were restricted to the tooth-bearing area and there was no pathology in the bone structure or any incidental findings in the region of temporomandibular joint. Unlike hypothesized, 27% of the orthodontic DPTs showed caries in deciduous teeth and 16% in permanent teeth. A sub-sample of 229 DPTs, analysed for developmental dental and occlusal problems, most commonly displayed crowding (50%), positional anomalies and local problems with tooth eruption (32%), as well as hyperodontia (15%). **Conclusion** Inclusion of only the actual area of interest in the image field should be considered case-specifically as a means to reduce the radiation dose.

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Introduction

For making a diagnosis and treatment plan, information obtained from radiographs is in many cases of vital importance. Yet, any radiographic examination is potentially hazardous. Children are more radiosensitive than adults and they have a greater potential for manifestation of possible adverse effects of ionizing radiation, because of growth and their longer remaining life expectancy.[1] The Radiation and Nuclear Safety Authority in Finland, with a central role in radiation protection, has paid attention to the large numbers of dental radiographs taken of children. Their reports substantially revealed that, among all conventional radiographic examinations of 7–12-year-old children in Finland, dental panoramic tomography (DPT) was the most frequent type of examination.[2]

Our previous analysis on a random sample from 2010 in Helsinki, Finland, showed that within this age group as many as 95% of DPTs were ordered for orthodontic reasons. Nevertheless, in 60% of cases, the referring professional was a general practitioner.[3] Therefore, all dentists involved in the treatment of children are in a decisive role when it comes to their total load of ionizing radiation.

Since the load and consequent risk can be effectively cut down by reduction of the exposed area it is important to delineate which area contains the information one needs for the purposes of diagnosis and treatment planning. The present study accordingly aimed at defining that area by exploring the type and location of pathologic and diagnostically important developmental findings in DPTs.

Materials and methods

DPTs taken of 7–12-year-olds were retrospectively collected among the patients and under the permission of the Oral Healthcare Department of the City of Helsinki, Finland, and analysed anonymously. Collection and age distribution of a random sample of 241 DPTs from 2010 has been described earlier.[3] An additional random sample comprising 200 children was collected as follows: In 2013 we received a list containing all the patients born in 2001–2006 and in 2014 of those born in 2002–2007 who had been exposed to DPT. From this list of 3883 patients every 20th patient, on average, was picked. Only those that had been imaged with an adult programme were accepted, to ensure that condyles were included in the irradiated field.

CONTACT Elmira Pakbaznejad Esmaeili elmira.pakbaznejad@helsinki.fi Oral Radiology, Department of Oral and Maxillofacial Diseases, PO Box 41, FI-00014 University of Helsinki, Finland

Files of altogether 441 patients were picked from the electric patient information system Effica® (Tieto, Helsinki, Finland) and analysed for the indication of radiography. The digital DPTs were viewed using Digora® for Windows 2.5 software (Soredex Dental Malaysia, Helsinki, Finland) and high-quality Eizo MX210–FlexScan® monitors (Eizo Nanao Co, Hakusan, Japan) under optimal viewing conditions without reflection light. Inter-observer agreement between the first author (E.P.E) and the senior oral radiologist (M.E.) was measured from the radiographic analyses of 25 randomly picked DPTs using Cohen's Kappa with Microsoft® Excel (2007, Mountain View, California, USA).

Of the 241 DPTs from 2010, 229 (95%) had been performed for orthodontic reasons. Within this sub-sample the first author registered: (1) general pathologic findings, and (2) developmental dental and occlusal findings of diagnostic importance. Third molars were excluded from the study, because the timing of their development would not coincide with the younger ages included the sample.[4] Unclear points related to the interpretation of the radiographs were consulted with the senior orthodontist (J.W.-S.) and the senior oral radiologist. Tooth development was considered delayed when the development of a single tooth was below the 10th percentile, and accelerated when above the 90th percentile of the Finnish control population.[5] Tooth eruption was considered delayed or accelerated when the deviation was more than two standard deviations from the documented mean age at eruption, relevant for Finnish children.[6]

Since the first collection of material displayed high amounts of caries, unlike hypothesized, a second random sampling was performed in the form of 200 DPTs from 2013–2014. The 184 (92%) of them that had been taken for orthodontic reasons were analysed for (1) age of the patient at the moment of radiography, (2) gender and anamnestic data, (3) pathology in the condylar processes or bone structure, and (4) tooth-specific data with the emphasis on eruption and caries status.

Results

Inter-observer agreement

Table 1 shows the inter-observer agreement over both general pathologic findings and those related to dental development and occlusion. For generally delayed dental development Kappa value could not be measured because this feature was so rare.[7]

Background data of the patients

The age distribution of the patients is shown in Table 2. The sex distribution of the patients was almost equal with 203 males (49%) and 210 females (51%). Of the sample of 184 patients from 2013–2014, 15 (7.5%) had general health problems, including juvenile rheumatoid arthritis (one patient), intellectual retardation (two patients) and asthma (13 patients).

General pathologic findings

Within the total 413 orthodontic DPTs, no incidental findings were observed in the region of temporomandibular joint (TMJ) and neither were there any pathologic findings in the bone structure.

The type and prevalence of general pathologic findings in the tooth-bearing area were analysed in a greater depth in 229 DPTs (Table 3). By far the most common findings were signs of caries morbidity, i.e., dentinal caries, periapical inflammatory lesions around primary teeth, as well as amputated primary teeth. Abnormally thin enamel throughout the dentition was observed in five patients (2%) as a possible sign of amelogenesis imperfecta.

Developmental dental and occlusal findings

Among the 229 DPTs, taken for orthodontic reasons, the most common finding was crowding of the dentition, seen in 114 DPTs (50%), followed by positional anomalies and local problems with timing of eruption in 74 (32%) and hypodontia in 34 (15%). Further conditions specified in Table 4 were present in 5% or less. Other findings, not specified in Table 4, but present in six DPTs (2%), were asymmetrical position of non-erupted canines, premature eruption (upper left first premolar completely in occlusion in an 8-year-old patient), unusually inferior crypt position (the crypts of the lower canines and pre-molars located at the inferior mandibular border), as well as local delay in tooth formation (upper left second pre-molar at crypt stage at the age of 9 years).

Table 1. Inter-observer agreement over findings.

Type of finding	Cohen's Kappa value	Strength of agreement
Abnormal development of dentin or enamel	1	Perfect
Alteration in the condylar processes	1	Perfect
Altered morphology of teeth	1	Perfect
Amputated deciduous teeth	1	Perfect
Cyst, tumour or other abnormality in bone	1	Perfect
Dentinal caries in permanent teeth	1	Perfect
Dentoalveolar or maxillofacial fracture	1	Perfect
Ectopic eruption	1	Perfect
Hyperodontia	1	Perfect
Hypodontia	1	Perfect
Interference with the eruption	1	Perfect
Periapical inflammatory lesion of deciduous teeth	1	Perfect
Periapical inflammatory lesion of permanent teeth	1	Perfect
Signs of juvenile periodontitis	1	Perfect
Other conditions	1	Perfect
Crowding	0.675	Good
Pathologic resorption	0.647	Good
Dentinal caries in deciduous teeth	0.504	Moderate
Positional anomalies	0.531	Moderate
Delayed dental development	Could not be measured	

Table 2. Age distribution of the 413 7–12-year-old orthodontic patients.

Age (in years)	Number and frequency (%) of the patients
7	59 (14%)
8	77 (19%)
9	100 (24%)
10	74 (18%)
11	67 (16%)
12	36 (9%)

Table 3. General pathologic findings from 229 DPTs of 7–12-year-old orthodontic patients.

Type of finding	Number of DPTs	Frequency (%) out of 229 DPTs
Dentinal caries in deciduous teeth	56	24
Dentinal caries in permanent teeth	32	14
Amputated deciduous teeth	5	2
Abnormal development of dentin or enamel	5	2
Periapical inflammatory lesion of deciduous teeth	3	1
Periapical inflammatory lesions of permanent teeth	0	0
Signs of juvenile periodontitis	0	0
Dentoalveolar or maxillofacial fractures	0	0
Cyst, tumour or other abnormality in bone	0	0

Table 4. Developmental dental and occlusal findings from 229 DPTs of 7–12-year-old orthodontic patients.

Type of finding	Number of DPTs	Frequency (%) out of 229 DPTs
Crowding	114	50
Positional anomalies (impacted, displaced, migrated or rotated teeth, infraocclusion, transposition), delayed eruption of a single tooth or eruption clearly behind of contralateral	74	32
Hypodontia	34	15
Altered morphology of teeth (dens invaginatus, dilaceration, peg-shaped incisors)	11	5
Delayed dental development in general	11	5
Hyperodontia	5	2
Pathologic resorption due to ectopic eruption	5	2
Ectopic eruption	5	2
Interference with the eruption (odontome, hyperodontia, malposition)	2	1
Alteration in the condylar processes	0	0
Other conditions	4	2

The type and distribution of developmental problems that can be attributed tooth-specifically are shown in Figures 1 and 2 for deciduous and permanent teeth, respectively. Crowding or any of the general pathologic findings are not included in these graphs. Findings related to dental and occlusal development were most frequently located in the region of permanent maxillary lateral incisors, followed by regions of mandibular second premolars and maxillary left second premolars.

Caries status

From the total 413 DPTs, taken for orthodontic reasons, 129 (31%) showed radiologically detectable dentinal caries. Dentinal caries of deciduous teeth was observed in 110 DPTs (27%), and dentinal caries of permanent teeth in 67 DPTs (16%). Within the DPTs displaying caries, the number of decayed deciduous teeth was six at maximum (median = 2), and that of decayed permanent teeth nine at maximum (median = 1). The population mean number of deciduous teeth with caries lesions detectable in DPTs was 0.58 and that of permanent teeth 0.26 in these 7–12-year-olds. Fillings are not included in any of these data.

Dental health was analysed in relation to the status of eruption in greater detail in the sub-sample of 184 DPTs from 2013–2014. Among deciduous teeth, caries and fillings were predominantly observed in the first and second molars (Figure 3). Of the first upper deciduous molars present in the oral cavity, 14% (34/242) were decayed and 11% (26/242) were filled and, of those in the lower jaw, 8% (19/237) were decayed and 10% (24/237) were filled. Of the second upper deciduous molars present in the oral cavity, 12% (37/302) were decayed and 15% (45/302) were filled and, of those in the lower jaw, 13% (39/298) were decayed and 11% (34/298) were filled. In the sub-group of patients aged 7–9 years, one to several deciduous molars had been extracted because of caries in 21 patients (18%). Among permanent teeth, first permanent molars showed the highest prevalence of caries (Figure 4). Of the upper first permanent molars 98% had erupted and, of those, 7% (26/360) were decayed and 7% (25/360) were filled. Of the lower first permanent molars, 99% had erupted and, of those, 8% (31/364) were decayed and 10% (37/363) were filled. Extractions were few and confined to first premolars and were most probably due to orthodontic reasons.

Discussion

Since children are particularly sensitive to ionizing radiation, all radiography and the size of the irradiated field must be especially well planned and the benefit has to exceed the risk. The present study was, therefore, undertaken to assess the type and location of pathological findings in DPTs of 7–12-year-old children undergoing orthodontic treatment, to weigh the outcome of the radiography. This age group was chosen because DPT is the most frequent conventional radiographic examination during ages 7–12 years, according to the national records.[2]

Half of the DPTs displayed crowding, making it the most frequent finding in line with previous observations.[8] Crowding by itself is not, however, an indication for radiography because it can be observed clinically. In our study, positional anomalies and local problems with the timing of tooth eruption were the second most frequent group of findings and present in a third. Malposition has elsewhere been reported to be the most frequent finding.[9] In our material, the region of maxillary lateral incisors displayed the highest prevalence of any anomaly, including tooth agenesis, followed by the region of mandibular second premolars and maxillary left second premolar. As reported before, the most common sites of hypodontia coincided with other types of abnormalities.[10]

Hyperodontia occur in 1–4% and missing teeth in 3–10% of the population.[11] In this study, hyperodontia was prevalent in 2% and hypodontia in 15% of the patients, third molars excluded. Hypodontia is the most common developmental dental anomaly,[12] with a reported prevalence of 8% in the Finnish control population, third molars excluded.[13] The almost duplicated prevalence of hypodontia in our sample can be explained by the fact that our sample was a pure orthodontic sample with an expectedly higher number of numeric anomalies. In our study, hypodontia involved mostly

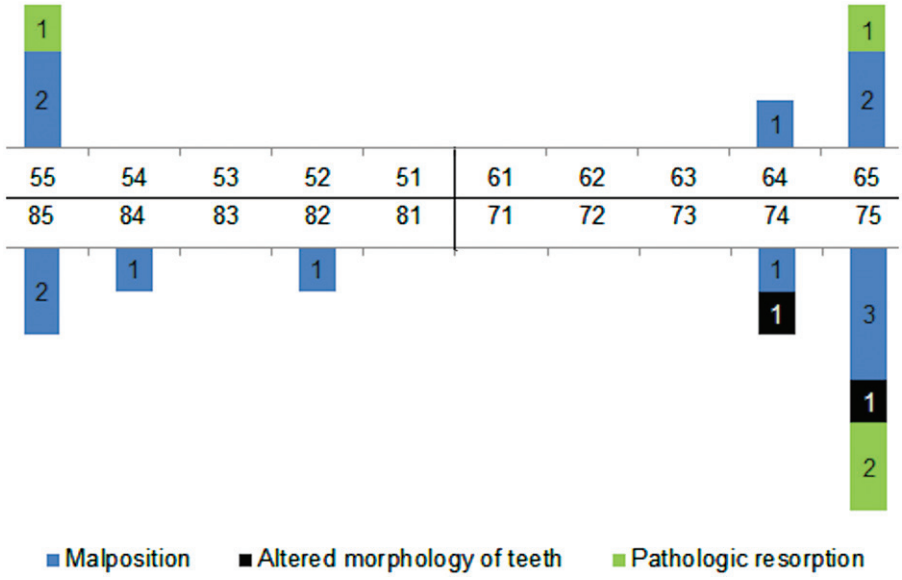

Figure 1. Distribution of the 19 developmental dental and occlusal findings among deciduous teeth in 229 DPTs of 7–12-year-old orthodontic patients. The teeth are numbered using the Federation Dentaire Internationale FDI two-digit tooth numbering system.

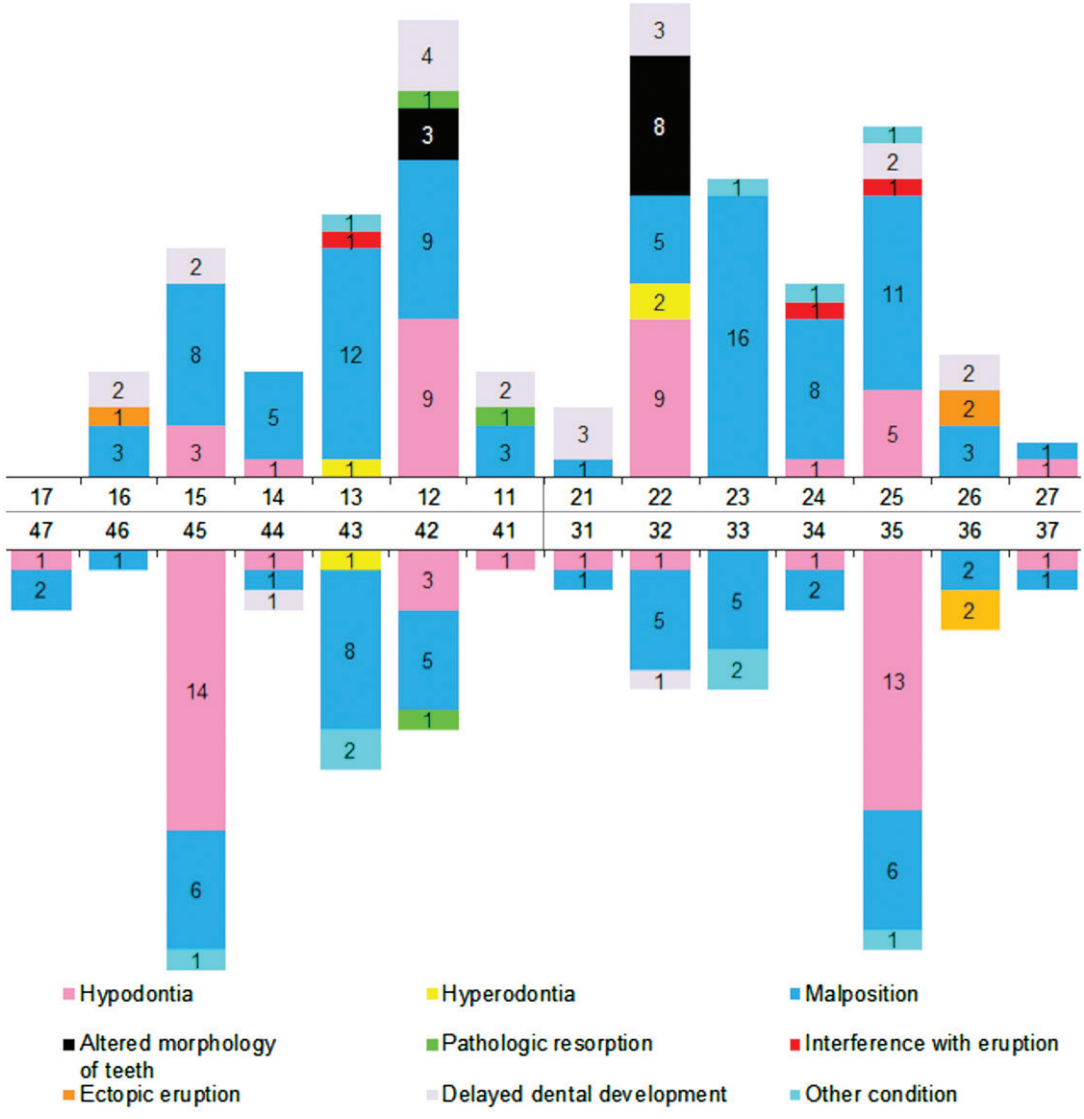

Figure 2. Distribution of the 254 developmental dental and occlusal findings, crowding excluded, among permanent teeth in 229 DPTs of 7–12-year-old orthodontic patients. The teeth are numbered using the FDI two-digit tooth numbering system.

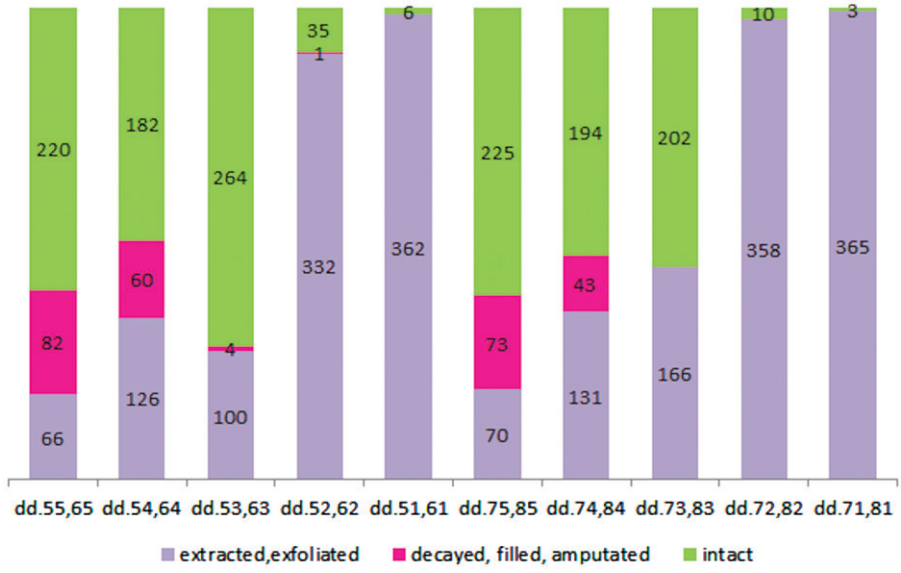

Figure 3. Presence and health status of the deciduous teeth in 184 DPTs of 7–12-year-old orthodontic patients. The teeth are numbered using the FDI two-digit tooth numbering system.

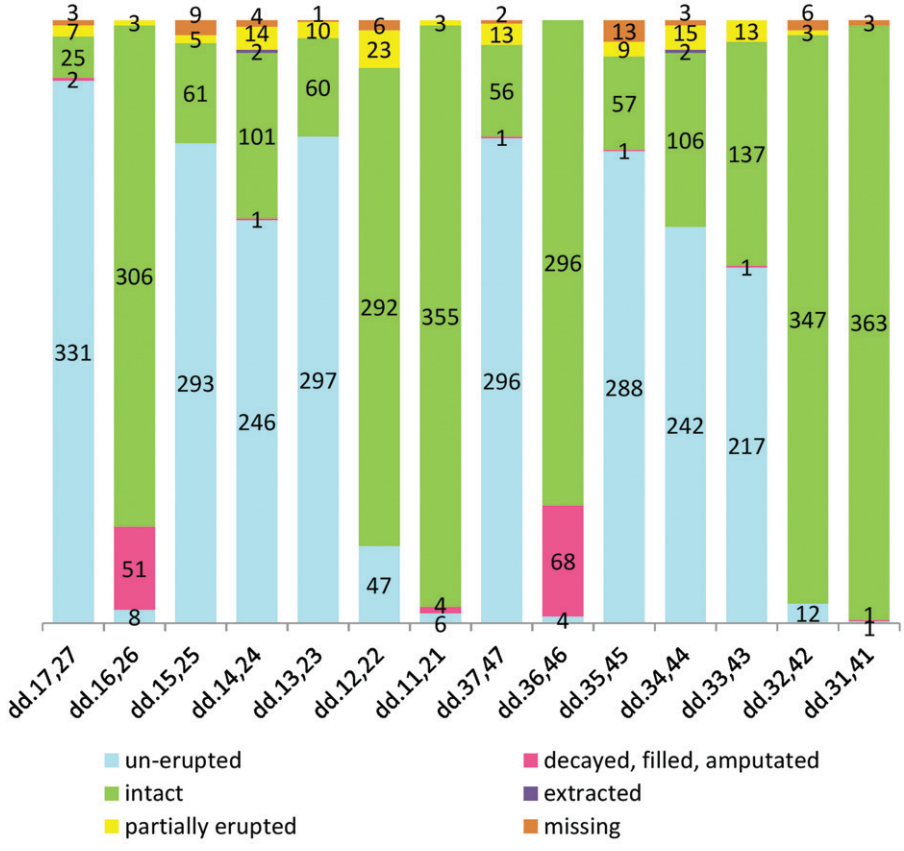

Figure 4. The status of eruption and caries among permanent teeth in 184 DPTs of 7- to 12-year-old orthodontic patients. The teeth are numbered using FDI two-digit tooth numbering system.

mandibular second premolars, followed by permanent maxillary lateral incisors and maxillary second premolars, in line with a previous report on Finnish children.[13] Similar, but not identical, the order of prevalence of missing teeth has recently been reported in other populations.[14]

Dentinal caries was the most common general pathological finding, displayed by 27% among deciduous teeth and 16% among permanent teeth. The proportion of teeth with untreated primary or secondary caries of all teeth with caries experience was 50% in deciduous molar teeth and 48% in

permanent molar teeth. These numbers are in line with the results of an earlier radiographic study performed on patients at the age of 14 years, in whom 57% of all detected dentin lesions were unrestored.[15] The prevalence numbers of caries in our study were high, given the fact that all our DPTs were ordered for orthodontic planning and therapy. This also emphasizes the importance of interpretation of the whole image, regardless of the indication of the radiography. On the other hand, children with severe carious lesions need more extractions prematurely, which leads to malocclusion.[16] and the need of orthodontic treatment. The moderate level of diagnostic agreement on dentinal caries of deciduous teeth in our study further stresses the general concept that DPT alone is not accurate enough for the diagnosis of proximal caries for the entire dentition and intra-oral bitewing radiography is superior to extra-oral imaging methods in detecting proximal caries in the area of premolars and molars.[17]

Regarding the overall location of findings in DPTs, very few findings have been reported to reside in the molar regions with almost all the findings of orthodontic significance locating mesial to the molars.[9] A confirmatory result of our study is that, from the total number of 254 developmental dental findings, only 25 (9%) were located in the region of molars, while the rest of them resided mesial to the first permanent molars.

The important question is how and to what extent either the diagnosis or the treatment plan of a particular patient is affected by radiological findings. In a previous report, only 26.5% of DPTs taken at 9–10 years of age and ordered by general dental practitioners have shown an anomaly of orthodontic importance or a finding of significance for orthodontic diagnosis and treatment planning.[18] On the other hand, the majority of paediatric dentists have been reported to believe in the equal importance of clinical and radiographic examinations for the treatment planning and diagnosis.[19] According to the same researchers in as few as 25% of cases pre-treatment radiographs may have an impact on orthodontic diagnosis, lateral cephalometric radiographs having the highest effect.[20] In adults, clinical examination supplemented with study models and photographs might often be sufficient for treatment planning [21] and a significant reduction in the numbers of radiographs is possible without risking treatment planning.[22]

In the present study we observed large numbers of findings within the developing dentition. The commonness of these findings makes the detection and exclusion of them equally important in a pre-selected orthodontic patient group. Hence, DPT of a developing dentition is powerful in detecting developmental and positional dental anomalies that had not been necessarily detected by clinical examination only. Our results are in line with the *Guidelines of Orthodontic Radiographs* of the *British Orthodontic Society* that state that additional information from DPT of a developing dentition is effective for assessment of the developmental status of the dentition, the morphology of un-erupted teeth, the necessity of extraction of primary teeth to prevent impaction of permanent teeth, the timing of orthodontic treatment, as well as the presence, extent and type of any developmental anomalies.[23]

In our randomly selected 413 DPTs all of the findings were located in the area of dentition. Importantly, there were no incidental findings in the region of TMJ. Dentists may be keen to look at the condyles in DPTs, although DPT may have a limited value for the evaluation of TMJ because of the distorted view of the joint and superimposition of skull base and zygomatic arch.[24] Cone beam computed tomography (CBCT) provides precise images from the bony structures of TMJ if required [25] and magnetic resonance imaging (MRI) is the imaging modality of choice if management of temporomandibular joint disorder (TMD) requires information about the soft tissues of the TMJ.[26]

The prevalence of degenerative changes of TMJ increases with age.[23] Congenital and developmental anomalies of TMJ, such as hemifacial microsomia (1/5600) and unilateral condylar hyperplasia (prevalence rarely studied), are rare conditions characterized by condylar growth abnormality, facial deformity and asymmetry.[27] Management of these patients may require three-dimensional treatment planning.[27] We agree that clinically observed facial asymmetry in children warrants inclusion of the condyles in the irradiated DPT field and complementary imaging.

Juvenile rheumatoid arthritis (JRA) is a rare condition with the incidence of 0.196/1000 in children under 16 years of age in the greater Helsinki area.[28] The onset of JRA is before the age of 16 years.[26] TMJ involvement is observed in 20–90%,[29] with the average of 41% in children.[26] The involvement of TMJ and associated radiographic changes usually occur in the late and advanced stages of the disease. The severity of these changes is usually related to the duration of the disease and, at this point, the diagnosis of JRA has already been established in most cases based on several clinical, radiographic and laboratory findings.[26] DPT might be used as a means for initial screening and provide a valuable view of condylar gross deformities, but it does not detect early radiographic signs of the disease.[26] Contrast-enhanced MRI is the image of choice for detection of early arthritic changes and other soft tissue abnormalities.[26,29]

The role of pre-treatment radiographs in the case of TMJ dysfunction symptoms developing during or after orthodontic treatment is discussed widely in the *British Orthodontic Society Guidelines of Orthodontic Radiographs* and articles cited in that guideline. According to them, symptoms of TMJ, (myofacial) pain dysfunction syndrome, may develop during orthodontic treatment, especially if there was some degree of problem at the start of the treatment. These symptoms are, however, mostly due to soft tissue problems and the bony components of TMJ are usually normal. Conventional radiography in TMJ dysfunction syndrome has limited value and is not recommendable or justified in order to avoid possible later claims of negligence.[23]

In a retrospective study on DPTs of Finnish 9–25-year-olds it was shown that radiographic condylar changes, such as flattened articular surface and subchondral sclerosis, are more common in orthodontically treated patients after the orthodontic treatment than in the controls.[30] In Finnish children with a mean age of 11 years and receiving orthodontic treatment, only the Angle class II molar relationship among morphological malocclusions and activator treatment among

different orthodontic treatment modalities have been seen to be associated with condylar changes in DPTs.[31,32]

To conclude, the present assessment of the type and location of findings in DPTs of 7–12-year-old orthodontic patients showed that caries was the predominating pathologic finding. This stresses the need of careful interpretation of all structures included in the field, irrespective of the indication for exposure. On the other hand, there were no signs of pathology outside the tooth-bearing area. Hence, we encourage new thinking and case-specific consideration of what the irradiated field should cover. Collimation of DPT to the actual area of interest can be considered as a part of good practice in the use of ionizing radiation and as a means of radiation protection, as recommended by the European Commission (2004).[22]

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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