

Frequency of errors and pathology in panoramic images of young orthodontic patients

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SUMMARY The aims of this study were to evaluate the frequency of errors in panoramic radiographs in young orthodontic patients, to register pathologic and abnormal conditions, and to compare these findings with the patient's record.

A total of 1287 panoramic radiographs of children and adolescents (530 boys and 757 girls; mean age 14.2 years) were analyzed. The radiographs were obtained of patients referred for orthodontic treatment during a 1 year period. Four observers evaluated the radiographs for 10 common errors, pathologies, and/or anomalies. Cohen's kappa was used for the calculations of inter- and intraobserver variability. Five of the errors were divided into clinically relevant or not clinically relevant errors, i.e. errors influencing diagnosis. Only those pathological findings with a possible influence on orthodontic treatment were compared with the patient's record.

Of the 1287 radiographs, 96 per cent had errors. The number of errors in each image varied between 1 and 5, and in 24 per cent of these images, the errors could be of importance for clinical decision making. The most common error was that the tongue was not in contact with the hard palate. Pathologies or anomalies were found in 558 patients and a total of 1221 findings were recorded. Findings of possible relevance for orthodontic treatment were 63, and 12 of those were registered in the patient records. Pathological findings outside the dental arches were low and could be an argument for minimizing the radiation field.

Introduction

Panoramic radiographs are often used as a diagnostic tool in orthodontic treatment planning. Compared with intraoral radiographs, panoramic radiography portrays not only the dental arches but also the surrounding structures in the maxilla and mandible. Bondemark *et al.* (2006) found that pathology and abnormality were diagnosed in panoramic radiographs of almost every 10th orthodontic patient, even though few of the findings required treatment.

However, the panoramic image also has its disadvantages, e.g. it is not sufficient for diagnosis of caries or periapical and periodontal disease due to the lack of image sharpness (Molander *et al.*, 1995). Positioning errors are common, limiting the possibilities of detecting pathological conditions. The occurrence of positioning errors is, among other factors, dependent on operator skill. Since panoramic radiography has a fixed sharp image where the basal part of the jaw has to be placed during the rotational movement, the technique depends on correct positioning of the patient, otherwise distortion can arise and objects or findings important for clinical decision making may be situated

outside the sharp image (Langland *et al.*, 1989). Another common error, related to the cooperation of the patient, is that the dorsum of the tongue is not in contact with the hard palate during exposure, and thus an air shadow of the oral cavity between the tongue and the hard palate may obscure any periapical pathology of the maxillary teeth (Schiff *et al.*, 1986; Rushton *et al.*, 1999; Akarslan *et al.*, 2003).

The aims of this study were to evaluate the frequency of errors in panoramic radiography in young orthodontic patients, to record the prevalence of pathological and abnormal conditions, and to compare a number of those findings of relevance for treatment with the findings registered in the patient's orthodontic record.

Materials and methods

A total of 1287 panoramic radiographs of children and adolescents (530 boys and 757 girls) with a mean age of 14.2 years (SD = 2.45) were retrospectively analyzed. The radiographs were taken by five specially trained orthodontic assistants and evaluated at the Clinic of Orthodontics, Public

Dental Service, Göteborg, Sweden. The study population consisted of all patients referred to the clinic during a 1 year period, except those with a cleft palate and craniofacial disorders. All digital panoramic images were obtained with an Orthopantomograph® OP100 D (Instrumentarium Dental, Tuusula, Finland) operating with automatic exposure control and the same field of view.

All radiographs were re-evaluated at the Clinic of Oral and Maxillofacial Radiology. Four observers participated in the evaluation, three oral radiologists with 20–30 years experience and one postgraduate student in oral and maxillofacial radiology. Each radiologist evaluated 300 randomly selected images, while the postgraduate student evaluated the remaining 387 radiographs. Subjective enhancement of radiographs was applied using the inherent enhancement facilities of the software (CliniView 6.1.3, Diagnos program for Orthopantomograph® OP100 D, Instrumentarium Dental). The images were displayed on a monochromatic screen (Olörin Medic Line ML 187D TFT-LCD, Olorin AB, Kungsbacka, Sweden) with a resolution of 1280 × 1024 pixels. The radiographs were manipulated to obtain good subjective density and contrast. For each radiograph, the observers registered the presence of errors together with pathology and/or anomalies.

The radiographs were evaluated according to:

1. Chin and occlusal plane rotated upwards.
2. Chin and occlusal plane rotated downwards.
3. Widening of anterior teeth.
4. Blurring of anterior teeth.
5. Rotation of the head to the right.
6. Rotation of the head to the left.
7. Lower border of mandible not visible on the image.
8. Tongue not in contact with hard palate.
9. Temporomandibular joints off the image.
10. Foreign objects and/or other errors.

The following five errors; upward and downward tilt, rotation of the head, and incorrect tongue position were divided into clinically relevant or not clinically relevant errors with respect to the diagnostic ability of the images. An error was classified as clinically relevant whenever it deteriorated the image quality to such an extent that it should have been retaken.

Several months after the first evaluation, the four observers made double recordings of the errors of 30 randomly selected images to determine intraobserver variability.

Pathological findings registered on the panoramic radiographs were compared with those noted by the clinician at the orthodontic department in the patient record. The comparison included only those findings with an expected influence on orthodontic treatment.

Descriptive statistical analysis of frequencies was used and image errors were independently assessed using Cohen's kappa test and inter- and intraobserver variability was calculated.

Results

Of the 1287 panoramic radiographs, 1236 (96 per cent) were assessed to have errors. The number of errors in each image varied between 1 and 5, the majority of the images had ≥ 2 errors (Figure 1a). The distribution of different errors is shown in Table 1 and clinically or non-clinically relevant errors in Figure 1b. The most common error ($n = 972$, 79 per cent) was that the tongue was not in contact with the hard palate (Figure 2). For 24 per cent ($n = 230$) of these images, the error was regarded as having a negative influence on diagnostic ability. Rotation of the head to the left was also common and in 18 per cent of these images diagnosis might be limited. The number of images with foreign objects (e.g. earrings, necklaces, nose and tongue piercing, hair slides) and other errors (e.g. patient movement, incorrect machine rotation) was small, only 37 (2.9 per cent).

Kappa values for the intraobserver agreement when reporting errors were good, 0.66–0.77, and the agreement 91–92 per cent. The agreement between observers was 84–93 per cent, corresponding to a kappa value between 0.31 and 0.66. The frequency of errors for each observer is shown in Figure 3.

Pathology and anomalies were reported in 558 patients (43 per cent) and a total of 1221 findings were detected. The majority of the findings were in the dento-alveolar regions, 522 in the upper jaw and 539 in the lower jaw. The number of pathological findings and anomalies in each patient varied between 1 and 14. A majority of the patients (47 per cent) had one finding and 29, 11, and 13 per cent had two, three, four, or five, respectively. The most common finding was hypodontia ($n = 497$, 41 per cent) in the permanent dentition and apical root resorption ($n = 112$, 9 per cent). Table 2 summarizes the pathological findings and anomalies in the dento-alveolar regions.

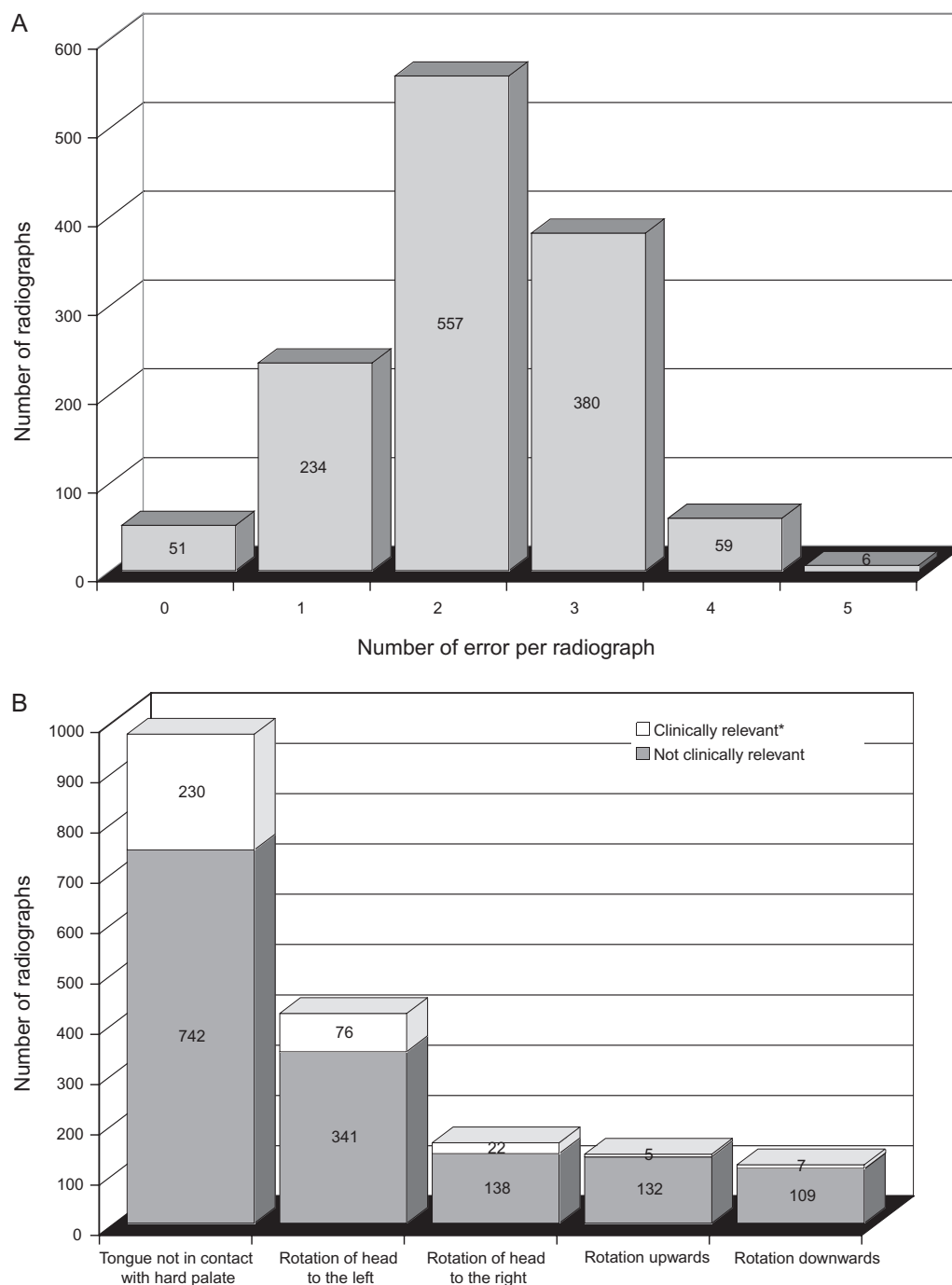
Of the 1221 pathological changes, 160 (13 per cent) were found outside of the tooth-bearing regions (Table 3).

Pathological findings that may have an influence on orthodontic treatment were 63 (5 per cent) of all findings (Figure 4). Of these, 12 were registered in the orthodontic records. Figure 5 shows an example of one of the non-registered findings.

Discussion

The panoramic technique is susceptible to a variety of unique errors. This was demonstrated by the results of this study where only 4 per cent of 1287 panoramic radiographs were subjectively evaluated to be without positioning errors.

The quality of panoramic radiographs depends to some extent on the skill of the operator. In this study, all radiographs were taken by experienced technicians at the same orthodontic clinic. The results may therefore not be applicable for panoramic radiographs in general. However, the clinic is one of the largest in Sweden with approximately



* 25 images had >1 disturbing error

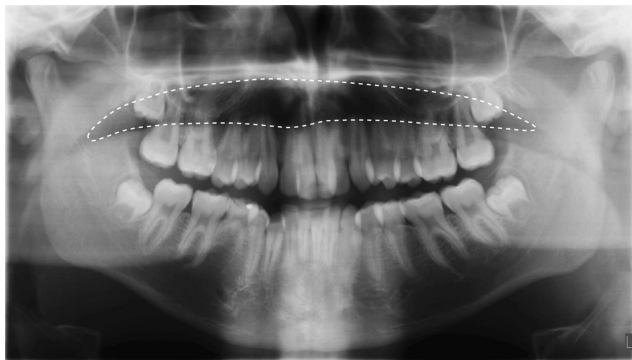
Figure 1 Distribution of panoramic radiographs ($n = 1287$) with (a) different number of errors and (b) clinically or non-clinically relevant errors.

1100 new orthodontic patients per year and the number of panoramic radiographs taken each year is therefore high. As the frequencies of errors in panoramic radiographs have not been investigated in many studies, the results are therefore difficult to compare with other clinics and departments. The number of positioning errors occurring in a specialist clinic for oral radiology is not known.

Schiff *et al.* (1986) reported that 80 per cent of panoramic radiographs had errors and, in a similar study by Rushton *et al.* (1999) 33 per cent of radiographs of adult patients were unacceptable. The frequency of errors in panoramic radiographs taken of adult patients in a radiology department of a dental school was high, 62 per cent, as reported by Akarslan *et al.* (2003). Paediatric patients were excluded

Table 1 Distribution of different errors in panoramic radiographs ($n = 1236$) with registered errors.

Type of error	<i>n</i>	%
Tongue not in contact with hard palate	972	79
Lower border of mandible off image	850	69
Rotation of the head to the left	417	34
Rotation of the head to the right	160	13
Chin and occlusal plane rotated upwards	137	11
Chin and occlusal plane rotated downwards	116	9
Blurring of the anterior teeth	66	5
Foreign object/other errors	37	3
Widening of the anterior teeth	35	3
Temporomandibular joints off image	26	2

**Figure 2** An example from one of the patients in the study of the most common clinically relevant error; tongue not in contact with the hard palate.

from that study because errors, such as movement and positioning, were considered to occur at a higher rate in young patients thus affecting the results.

The most common error in the present study was that the tongue was not placed in contact with the hard palate during exposure, a result also in concordance with the findings of Schiff *et al.* (1986) and Akarslan *et al.* (2003). An incorrect

Table 2 Different pathologic and abnormal findings in tooth-bearing regions, including the third molar region.

Findings	<i>n</i>
Hypodontia	497
External root resorption	112
Impacted tooth	109
Retained root of a primary molar	102
Idiopathic osteosclerosis	98
Supernumerary teeth	30
Altered tooth morphology	24
Periapical inflammatory lesion	24
Hyperplastic follicle*	23
Displaced tooth	19
Cystlike lesion**	13
Other***	3
Marginal bone loss	3
<i>Dens invaginatus</i>	2
Internal root resorption	1
Dilaceration of the root	1

* >3 mm to ≤ 5 mm.

**Range ~ 10 to 25 mm \varnothing .

***For example, abnormal bone pattern, healing defects.

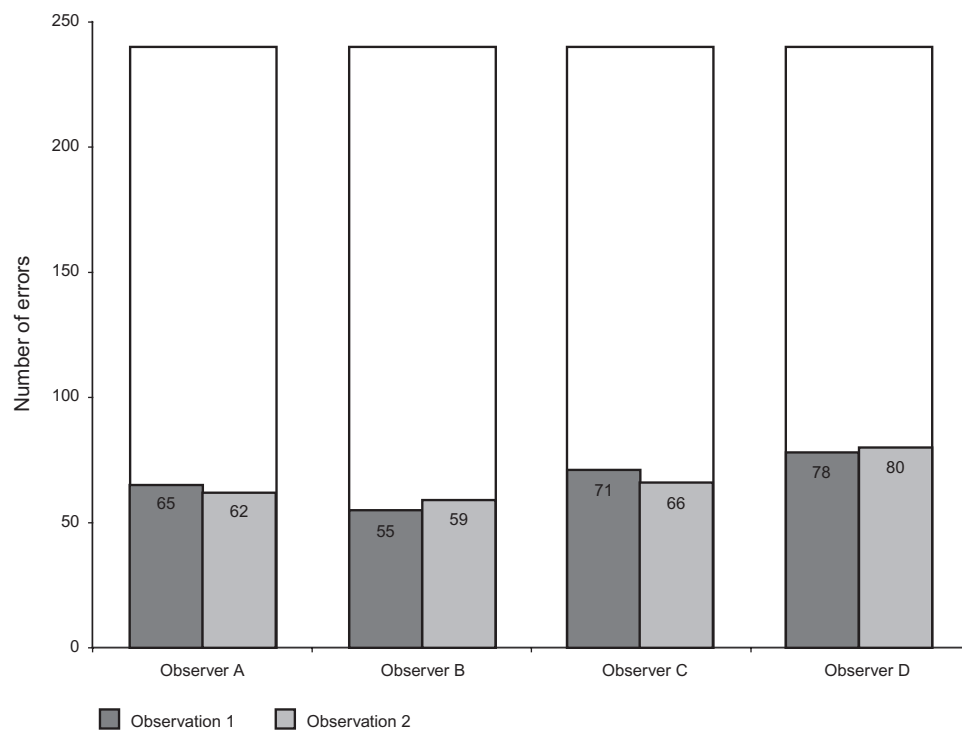
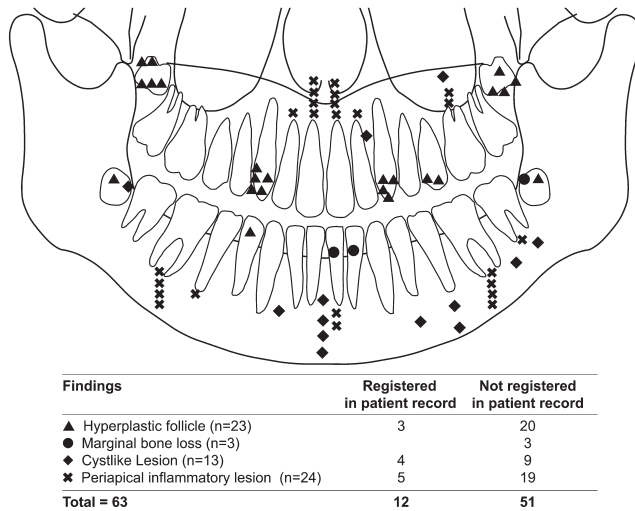
**Figure 3** Variability within and between observers reporting errors. The number of estimated errors was in total 240 in the 30 images that were re-evaluated.

Table 3 Different pathologic changes outside tooth-bearing regions.

	<i>n</i>
Maxillary sinus mucosal thickening	118
Deviation in form of the mandibular condyle	32
Hyperosteoses/bone sclerosis	4
Soft tissue calcification	3
Reduced size of the mandibular ramus	3

**Figure 4** Anatomic location for pathological findings ($n = 63$) relevant to orthodontic treatment.

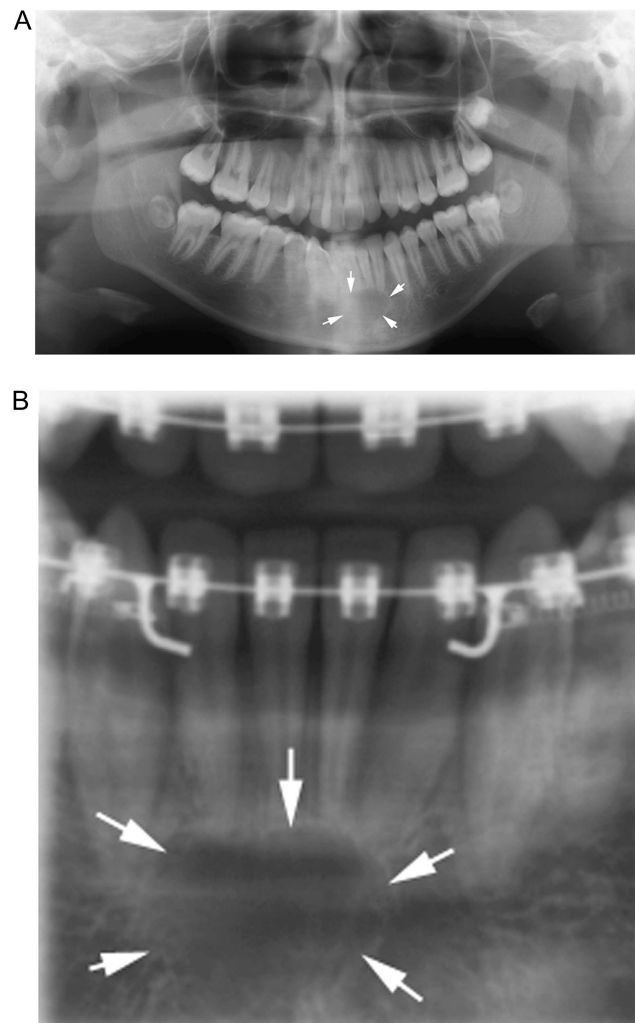
tongue position can affect diagnoses of apical periodontitis and assessments of root anatomy and resorption, findings that might be of importance for orthodontic treatment and one of the reasons for taking the radiographs.

Another common error was that the patient's head was rotated, more often to the left than to the right. This systematic error can be explained by the construction of the panoramic equipment where the positioning aids are on the patient's left side.

The present study showed that 315 (25 per cent) out of 1287 radiographs should have been retaken as the radiographs had clinically relevant errors. If the image is not retaken, the diagnostic value of the radiograph, and thus the radiation dose and benefit for the patient, is questionable. This decision needs to be made by the treating clinician.

All observations are susceptible to variations within or between observers. The agreement in this study was acceptable both within and between most of the observers when evaluating positioning errors.

The results from the second part of the study were that 43 per cent of the radiographs showed signs of pathology and/or anomalies and of these, 7.8 per cent were considered by the observers, to require treatment. The most common findings were hypodontia in the permanent dentition, maxillary sinus mucosal thickening, and apical root resorption. These findings

**Figure 5** (a) An example of a cyst-like lesion, a simple bone cyst (arrows) in the lower anterior jaw not registered in the patient's record. (b) The same lesion (arrows) depicted in a dental radiograph (extraoral scanogram).

were made from the radiographs only and it is well known that some uncertainty can arise with all types of radiographic assessments made without clinical examination. Few studies have analyzed the prevalence of different pathological and abnormal findings in children and adolescence requiring orthodontic treatment. In earlier publications, the frequency in a young population varied between 6.2 and 8.7 per cent (Kuhlberg and Norton, 2003; Bondemark *et al.*, 2006).

Changes in the mandibular condyle were rare, 2.6 per cent. The radiographic appearance of normal condyles in children and adolescents may show little or no evidence of the cortical border and result in false-positive findings (White and Pharoah, 2009). Therefore, the need for imaging the temporomandibular joints in young patients without any clinical symptoms of joint disorder is questionable.

In the present study, 118 of 160 findings outside the dento-alveolar region were pathology in the maxillary sinuses, changes that rarely require treatment. The remaining

42 (3.4 per cent of all findings) would not have been detected if the field size had been reduced to the dento-alveolar arches. The impact of these findings on treatment outcome has to be weighed against the increased risk associated with a larger radiation field. In order to minimize the exposure to the patient, it is possible to reduce the dose by trimming the field size, i.e. decrease the width and height in panoramic radiography. A study by Svanaes *et al.* (1985) showed that if the field size was reduced to encompass the developing dentition only, a 60 per cent reduction of the dose was obtained. This is important especially for children in need of orthodontic treatment because they may be exposed to repeated radiographic examinations.

Only 12 of the findings considered to require treatment were registered in the orthodontic records. It is difficult to make any definite statement about the reason why pathological changes of importance for treatment were not registered. Few studies have determined the diagnostic accuracy of interpreting panoramic radiographs. Raitz *et al.* (2009) recently reported on the probability of correct identification of radiolucent lesions by undergraduate students and newly qualified dentists. Correct values were low for both groups. The discrepancy between the orthodontic records and the observations made by the oral radiologists in this study may be due to differences in opinion on what is a pathological finding of importance for orthodontic treatment planning as well as differences in experience and skill in interpreting panoramic radiographs. Furthermore, the viewing conditions differ, e.g. image display (default contrast enhancement versus individual adjustments of density and contrast), monitors (polychromatic versus monochromatic), and lightness in the room (operating room versus radiology department). The difference between the numbers of pathologies or anomalies registered by the radiologists but not registered in the patient record, stress the fact that orthodontists have to be both aware of the potential of pathological findings in young patients without clinical signs and symptoms as well as being more careful to note and register the findings in the patient's record. However, re-evaluation of the 1287 panoramic radiographs only resulted in 10 written remarks on findings that needed attention by other specialists.

Panoramic radiography is one of the most common radiographic examinations in orthodontic diagnosis and treatment planning, even though they might have only a minor effect on diagnosis and treatment decisions (Bruks *et al.*, 1999). Those authors found that in 93 per cent of the orthodontic patients studied, the initial treatment plan, based on clinical examination, study models and photographs coincided with the final treatment plan. Few studies have investigated the diagnostic reasons for taking panoramic radiographs in orthodontic patients. In a study by Atchison *et al.* (1992), the most common indication for radiography was the skeletal relationship of the jaws, followed by root formation/length and molar position or development.

This study, together with others (Schiff *et al.*, 1986; Akarslan *et al.*, 2003), has shown the frequent occurrence of errors in

panoramic radiography, i.e. how difficult it is to take panoramic radiographs without errors that may affect the diagnostic value of the radiographic examination. Pathological findings were low and the majority were found in the tooth-bearing regions. Few were registered in the patient's orthodontic records. Professionals responsible for the interpretation of radiographs have to be aware of the potential of finding symptom-free pathological changes or other anomalies, even though the frequency is low. In order to minimize the radiation burden to young patients, the radiation field could preferably be restricted to include the dento-alveolar regions only.

Conclusions

1. It is difficult to take panoramic radiographs without positioning errors.
2. Clinicians have to be aware of the potential of pathological findings in young symptom-free patients, even though the occurrence is low.
3. Few findings were registered in the patients' orthodontic records.
4. Pathological findings outside the dental arches were low.
5. The radiation field can preferably be restricted to include the dento-alveolar regions only.

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