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Research

Visual scan behavior of new and experienced clinicians assessing panoramic radiographs

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ABSTRACT

Objective: The aim of this study was to examine and compare the visual scan behavior of clinicians with different levels of experience during assessment of panoramic radiographs.
Methods: The visual scan paths of 20 dentists, 10 with 5 years of clinical experience or less (new clinicians) and 10 with more than 5 years of clinical experience (experienced clinicians), were recorded as they assessed five panoramic radiographs. Differences between groups were tested for statistical significance, and associations between level of clinical experience, viewing time, completeness, and detection of abnormality were computed.
Results: Experienced clinicians were significantly quicker ($P < 0.001$) and, more often than new clinicians, had a discernible scanning pattern. New clinicians often had no pattern to radiograph assessment, but they scanned the radiographs significantly more completely ($P < 0.001$), and their gaze scan paths entered more areas of abnormality. There were significant positive correlations between viewing time and completeness ($P < 0.001$), and between viewing time and detection of abnormality ($P = 0.042$) but not between level of clinical experience and detection of abnormality ($P = 0.054$).
Conclusions: Experienced clinicians have a faster and more systematic approach to panoramic radiograph assessment but tend to be less complete than new clinicians.

1. Introduction

A panoramic radiograph (PAN) is an important component of a patient's dental record. Its broad coverage makes a PAN useful in the evaluation of dental development and developmental anomalies, location of third molars, temporomandibular joint morphology, trauma, and pathology [1]. Traditionally, dental schools have educated students extensively in panoramic radiographic anatomy, but not all of them teach a systematic method of radiographic image assessment. This is remarkable, as establishing an assessment method early in one's career would seemingly increase the efficiency of radiographic image assessment. This, in turn, may result in earlier recognition of abnormality or pathology, a higher standard of clinical care, and better treatment outcomes.

It appears that an efficient method of radiographic image assessment is often developed with clinical experience. More experienced clinicians have been shown to be faster and more accurate at radiographic image assessment than less experienced clinicians [2–5]. Their broad knowledge base, particularly knowledge of the normal, built up by viewing large numbers of radiographs, enables them to quickly compare a radiograph with a mental representation of a typical normal image, which allows for rapid identification of abnormalities and more accurate and time-efficient interpretation [6]. For instance, in mammogram interpretation studies, the most experienced observers had the fastest search times in the detection and confirmation of breast masses, whereas inexperienced observers were less efficient and their search was often distracted by image artifacts that captured their visual attention [5,7]. Although they scanned far less image area and spent less time on image assessment, experienced observers noticed more pathology and had fewer false positive findings than inexperienced observers [8].

Although PANs differ significantly from mammograms in their complexity and coverage of the patient's regional anatomy, it is conceivable that with their assessment, too, a relationship exists between level of clinical experience and image assessment efficiency. Until now, no studies have addressed the visual sampling

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strategies of clinicians assessing PANs, and it is unknown whether any consistent method of image assessment is developed with clinical experience, or if a consistent method can improve the detection of abnormalities. Therefore, we aimed to examine and compare the PAN assessment methods of dentists with different levels of clinical experience. We hypothesized that more experienced dentists would have a quicker and more systematic approach to image assessment.

2. Methods and materials

The study protocol had Institutional Review Board approval (University of Minnesota, 0906P67401). Informed consent for eye-position recording was obtained from all participants. Patient informed consent for the use of anonymized radiographs was not required.

2.1. Observers

Twenty dentists participated as observers. None of them required corrective lenses. The observers were divided into two equal-sized groups: dentists with practice experience of 5 years or less (new clinicians) and dentists with practice experience of more than 5 years (experienced clinicians). The group of new clinicians consisted of four orthodontic residents, three orthodontists, one pediatric dental resident, one periodontal resident, and one general dentist. The group of experienced clinicians consisted of 10 orthodontists. All observers had received similar training in the assessment of PANs and used this type of radiograph on a regular basis in their clinical practice.

2.2. Panoramic radiographs

Five digital PANs, one showing a late mixed dentition and four showing early permanent dentitions, which had been taken as part of orthodontic diagnostic records on an orthopantomograph OP100D x-ray machine (Instrumentarium Dental, Tuusula, Finland), were used as a test set. Three of the PANs showed normal radiographic anatomy, whereas the fourth and the fifth PAN showed an inverted mesiodens near the apex of the maxillary left central incisor and apical root resorption of the mandibular incisors, respectively, as significant findings. Mesiodentes and apical external root resorption of incisors have been reported to be prevalent in 0.15% to 1.9% [9] and 8.2% to 15.0% [10,11] of the general population, respectively. All PANs were read by an oral radiologist before the study to ensure that no abnormality or pathology was overlooked.

Each PAN was digitally divided into eight areas of interest (AOIs) using dedicated software (Eye-Trac, Applied Science Laboratories, Bedford, MA). Additional AOIs corresponding to the mesiodens and the area of root resorption were created in the two PANs with significant findings. This image compartmentation (Fig. 1) was invisible to the observers and was used to correlate each observer's visual scan path to the AOIs. The PANs were displayed on a 19-inch computer monitor with landscape screen orientation at a resolution of 1280 × 1024 pixels (1908FPC, Dell, Round Rock, TX).

2.3. Viewing procedure and data collection

A desk-mounted eye-tracking machine (Eye-Trac 6000, Applied Science Laboratories) was used to monitor each observer's visual scan path during assessment of the PANs, as detailed below. During data collection with this type of machine, the observer's head is stabilized in a chin rest, which is considered ideal for viewing stationary objects [12]. The machine was placed in a room with white walls, dim light, and no distractions in the observer's field of view.

The observers were asked to assess the PANs as they would for their patients and to indicate when they were finished with the assessment of each PAN. No information was given on the presence or absence of abnormalities or pathology to not influence the eye-movement pattern or reinforce the need for an extensive search [13]. The observers were informed that the study was not performed to test their diagnostic skills, their name would not be linked to any data, and each PAN would be displayed for 90 seconds unless they chose to end the assessment early. The display time was chosen on the basis of an initial trial, in which no PAN assessment took longer than 60 seconds. For the purpose of the present study, an extra 50% was added to this time span to not influence the participants to go through the radiographs more quickly than they would normally do.

Each observer viewed the PANs at an eye-to-monitor distance of 45 cm. Before the viewing procedure, the eye-tracking machine was calibrated for each observer using a nine-point calibration image [12]. The pretrial calibration patterns were used to determine proper alignment of the eye-movement pattern relative to the image. Each observer viewed a practice PAN to gain familiarity with the display, the recording procedure, and the time limit. During this practice run, the operator confirmed that the eye-tracking machine picked up the observer's eye position consistently.

Data collection began with the simultaneous display of a PAN on the monitor and the start of eye-position recording. The sequence in which the PANs were shown was randomized for each observer. Once the observers indicated that they were finished with their assessment, eye tracking was discontinued, and the recording was stopped. The process was repeated until each observer had viewed all PANs. For post-trial calibration, each observer was asked to look at various points on the last PAN displayed. The post-trial calibration patterns were used to check for head movement during data

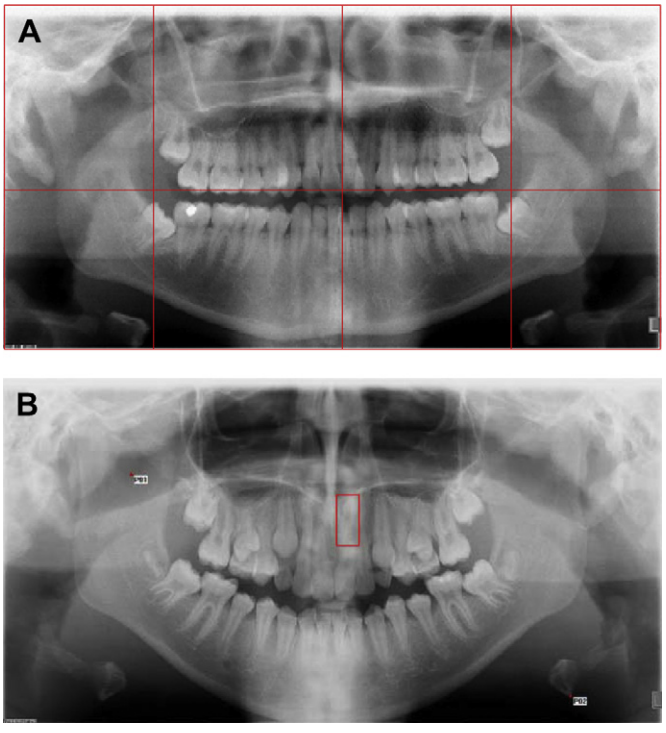

Fig. 1. Image compartmentation. (A) Panoramic radiograph (PAN) divided into eight areas of interest (AOIs). (B) Area of interest corresponding to the mesiodens as an example of the additional AOIs created in the PANs with significant findings.