

Visual Fixation and Scan Patterns of Dentists Viewing Dental Periapical Radiographs: An Eye Tracking Pilot Study

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Abstract

Introduction: The visual search patterns of dentists and the areas that attract their attention when interpreting dental periapical radiographs are currently unknown. This research identifies areas and patterns of visual fixation when observing dental periapical radiographs.

Methods: In an observational study using eye tracking technology and a convenience sample of 44 observers, the interpretations of 4 dental periapical radiographs were recorded using Camtasia Software (TechSmith, Okemos, MI) with a gaze tracking “bubble” denoting where within the radiograph the observers’ eyes gazed. The recorded observations included the scanning pattern, the area of first fixation, and revisits of areas. Also noted was whether the area of first fixation or revisit was radiopaque, radiolucent, or of normal radiodensity and whether it was a coronal or radicular area.

Results: The first fixation is more likely to be an area of high contrast that is either radiopaque or radiolucent compared with areas that were normal or of average gray scale. Significantly more revisits occurred on areas that were radiopaque and located in the radicular area. Of the 4 categorized scanning patterns, tooth by tooth scanning predominated. **Conclusions:** When interpreting dental periapical radiographs, significantly more observers initially fixated on areas of the radiograph that were of high contrast (ie, radiopaque or radiolucent) compared with “normal areas.” A tooth by tooth scanning pattern was most commonly used. (*J Endod* 2018; ■:1–6)

Key Words

Dental, eye tracking, perception, periapical radiograph, radiography, x-ray

Clinical tests and periapical radiographs provide dentists with information for pulpal and periapical diagnoses. The interpretation of dental radiographs is a dual process that requires both perception and cognition (1). The visual scan of the radiograph is perceptual, whereas the diagnostic reasoning and decision making are cognitive (2). Dental research has documented some aspects of the cognitive interpretation of dental radiographs; however, minimal research has documented perceptual components of dental radiographic interpretation.

Two published studies in dental radiography have used computerized eye tracking technology to evaluate dentists’ perceptions of panoramic and computed tomographic images (3, 4). Computerized eye tracking technology allows researchers to specifically determine where an observer is gazing within an image and illustrates patterns in the scanning process. This is the first study to use eye tracking technology for dental periapical/endodontic radiographic interpretation.

Two essential components of perception are termed fixations and saccades. Fixations are locations where the observer’s gaze pauses momentarily. Along with the belief that perception is coincident with fixations is the idea that fixations are where cognition occurs (5). Individual fixations are separated by saccades, which are uniform movements of both eyes at a very high speed directing the gaze onto the next fixation. Some saccades may be voluntary, whereas many are not (6).

The purpose of this study was to use computerized eye tracking technology to determine visual fixation and scan patterns of observers when viewing dental periapical radiographs. The following parameters of interest were selected for examination: area of first fixation, revisits, search patterns, effect of radiodensity, effect of coronal or apical location, and differences between observer experience levels. The first null hypothesis of this study was that there would be no differences in fixations or revisits whether the structure was located in a coronal or radicular area or was of normal radiodensity, radiopaque, or radiolucent. The second null hypothesis was that there would be no difference between the scan patterns and the percentage of pathology, coronal, intraradicular, and periapical areas scanned. A third null hypothesis was that there

Significance

The visual search patterns of dentists and the areas that attract their attention when interpreting dental periapical radiographs are currently unknown. This is the first study to use eye tracking technology for dental periapical/endodontic radiographic interpretation. Using eye tracking technology, this research identifies areas and patterns of visual fixation of observers viewing dental periapical radiographs.

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Clinical Research

would be no difference in scan patterns between observer groups of different types or experience levels.

Materials and Methods

This study was performed in accordance with a protocol approved by the Institutional Review Board of Saint Louis University, St Louis, MO. A convenience sample of 44 observers with differing years of experience and levels of training were recruited. These observers consisted of third- and fourth-year dental students ($n = 12$), advanced education in general dentistry residents ($n = 8$), general dentists ($n = 12$), and endodontists ($n = 12$). Observers were excluded if they were unable to visually calibrate the eye tracking device.

Digital periapical radiographs were obtained from patients treated at the endodontic clinic at the Saint Louis University Center for Advanced Dental Education. A Delphi panel consisting of 4 endodontists selected the radiographs to include a variety of radiographic findings including normal teeth, direct or indirect restorations, coronal caries, periapical radiolucencies, posts, and endodontic treatment. All radiographs had patient identifiers removed to maintain confidentiality. Four radiographs were selected for analysis: 2 from the maxillary arch and 2 from the mandibular arch (Fig. 1). Two were of the left side and 2 of the right side. Each periapical radiograph contained a first molar, second molar, and at least the second premolar. The full extent of a periapical radiolucency, if present, was visible in the radiograph. Six other radiographs were selected as “filler” or “practice” radiographs.

The radiographs were displayed on a 21.5-inch Apple iMac Desktop computer/monitor (Apple Inc, Cupertino, CA) using an automated PowerPoint presentation (Microsoft Corporation, Redmond, WA) with each of the 10 radiographs displayed in sequence for 10 seconds. The experimental radiographs were sequenced at positions 4, 5,

6, and 10. Data were collected using an optical video-based Tobii EyeX eye tracking device (Tobii Technology, Danderyd, Sweden), which illustrates gaze paths via an integrated 1.5-inch diameter gaze tracking “bubble” (Fig. 2A and B). A Camtasia Studio Software (TechSmith, Okemos, MI) recording of the display captured the path of the gaze tracking bubble. A digital video file preserved each observer’s gazes of the 4 radiographs. Observers first viewed introductory slides, which included a calibration exercise that ensured the Tobii EyeX could accurately track the observers’ gaze. Observers were instructed to interpret the radiograph as if a patient was waiting in the chair, that the radiographs would cycle automatically after 10 seconds, and to disregard the gaze tracking bubble.

The Camtasia digital video files of the 4 experimental radiographs were blinded by an unassociated individual using a random number generator. Two blinded researchers then performed evaluations of the Camtasia recordings. When there was disagreement between the 2 evaluators in categorizing data, a consensus was reached after a discussion. In all instances, a consensus was able to be reached. Data from the other 6 radiographs were not evaluated.

The observers’ area of first fixation was noted, defined as the first region of a definitive stop of the eye along the scan path. This area was categorized by location and radiodensity as coronal or radicular/periapical and normal, radiopaque, or radiolucent. The Delphi panel defined these categorizations. Radiopaque was defined as an area on the radiograph with radiodensity significantly greater than the average gray scale of the radiograph. These areas included metal restorations or root canal obturating materials. Radiolucent was defined as an area on the radiograph with radiodensity significantly lower than the average gray scale of the radiograph. These areas included periapical radiolucencies or carious lesions. Normal was defined as areas on the radiograph that were within the expected gray scale of the radiograph.



Figure 1. The 4 experimental radiographs.

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