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The influence of coronal tooth tissue in the diagnosis of apical pathosis

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Abstract

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Aim To assess the influence of the status of the crown of the tooth on the observers' periapical radiological assessment.

Methodology Seven clinical tutors, eight postgraduate students and seven undergraduate students were recruited. Each evaluated 24 periapical radiographs comprising 12 radiographs with teeth restored with small to medium coronal restorations and 12 radiographs displaying teeth which were either heavily restored or exhibited gross caries. Two viewing sessions, separated by several weeks, were undertaken using ideal viewing conditions. In the first viewing teeth were examined in their entirety and in the second the coronal aspects of the teeth were obscured.

Results An analysis of variance found no significant differences between the groups of observers during the first viewing. When the crowns were masked, undergraduate students had a significantly lower sensitivity ($P = 0.008$) compared with postgraduates and clinical tutors. Paired *t*-tests found a significant increase in the sensitivity of the postgraduate students between the first and second viewing ($P = 0.037$). Mean sensitivity and specificity for the undergraduates decreased from 0.67 to 0.63 and 0.64 to 0.60 for the first and second viewing, respectively, whilst mean sensitivity for postgraduates and clinical tutors increased from 0.59 to 0.79 and 0.69 to 0.80, respectively. Specificity increased from 0.72 to 0.78 for the postgraduates between viewings, whilst the tutors recorded 0.80 for each viewing.

Conclusion The status of coronal tooth tissue had a major impact on the diagnostic accuracy of the observers with limited radiological experience supporting the need for earlier radiological training within the undergraduate curriculum.

Keywords: diagnosis oral, diagnostic errors, observer variation.

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Introduction

The presence of early apical periodontitis is seen radiographically as changes affecting the periapical tissues such as widening of the periodontal ligament space and a lack of continuity of the lamina dura (Lee 2006). However, several studies (Goldman *et al.* 1972, 1974, Abdel-Wahab *et al.* 1984, Bohay 2000) found that a wide degree of variation existed amongst clinicians when interpreting radiographs for the presence/absence of apical changes. This variation in inter-observer reliability can be affected by various factors including the education, training and experience of the observer (McCaul *et al.* 2001) and also the viewing conditions (Patel *et al.* 2000). Radiological interpretation has also been shown to be affected by the mental state of the examiner (Goldman *et al.* 1972). However, the influence of the status of coronal tooth tissue appears never to have been a factor considered by the observer when assessing the periapical region for the presence or absence of apical change.

The aim of this study was to determine whether masking of coronal tooth tissue had any influence on

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the ability of a number of observers, with varying levels of radiographic interpretative skills, to correctly assess the periapical status of the tooth under consideration.

Materials and methods

The films used in this study were obtained from clinical files of discharged patients at a UK Dental School. These files had been removed from the hospital record department prior to being destroyed, which was in line with hospital policy, as each of the patients had not attended for a clinical appointment within the last 10 years.

The clinical notes were meticulously reviewed to ensure that the patient had presented with signs and symptoms to support a diagnosis of the presence of periapical pathology and, also, that the diagnosis had been supported by both clinical and radiographic findings. The patient records contained a complete report of special tests such as the response to percussion, thermal and electrical pulp testing. In the majority of cases, the clinical notes also recorded that the patient had subsequently undergone root canal treatment on the tooth under consideration or that the tooth had been extracted. Similarly, the discharged clinical notes also provided the researchers with periapical films of teeth having no clinical or radiological evidence of apical pathology.

Each radiograph was examined by two Consultant Radiologists specializing in Dental and Maxillofacial Radiology. A consensus assessment of the presence or absence of apical pathology was made. This involved simultaneous viewing of each of the radiographs by the two experts using ideal viewing conditions comprising a standard 15 by 30 cm light box in a room with subdued lighting and ×2 magnification. Each film was viewed on two occasions separated by 7 days. No film was accepted for this study if there was disagreement between the observers as to presence/absence of apical pathology. For the latter, the periapical tissue had to exhibit a widening of the periodontal ligament space, a loss of the lamina dura or a combination of both.

Each of the radiographs had been processed using automatic processing techniques which were subjected to a continual assessment of processor performance. This was achieved by the use of routine daily densitometric analysis. Twenty-four radiographs were finally chosen which fulfilled the requirements of the research protocol. The films were divided into two groups. The first group consisted of 12 periapical radiographs that showed teeth restored with small to medium sized coronal restorations. The second group consisted of 12 periapical radiographs of teeth which were either heavily restored or had gross caries. Within each of these two groups, the radiographs were further subdivided into two groups, each containing six radiographs. Of these, the first group consisted of six radiographs of teeth which displayed early signs of apical pathology, i.e. widening of the periodontal ligament space and/or loss of the lamina dura, whilst the second group showed no radiological evidence of apical pathosis. The 24 radiographs chosen comprised 10 films taken within the maxilla and 14 films of mandibular teeth. Each group contained examples of incisor, canine, premolar and molar teeth.

Seven undergraduate students, eight postgraduate students and seven clinical tutors agreed to participate in the study. Each observer was given a unique identification number to ensure anonymity but one which allowed the researchers to distinguish between the three groups of observers. The films were viewed on two separate occasions using optimal viewing conditions. These consisted of one X-ray viewer (SDI X-ray Magnifier; Trycare Ltd, Bradford, UK) with integral ×2 magnification and a light box (Rinn; Densply, Weybridge, UK). The light box had been fitted with a new fluorescent bulb prior to the commencement of the trial and the viewing surface was routinely cleaned prior to each film viewing session. Lightmeter and photometer analysis was undertaken prior to each viewing session to ensure standardized viewing conditions.

Before the first viewing, the 24 periapical films were randomized and mounted with peripheral masking. The participants were instructed to detail whether apical pathosis was present or not on specific root apices. After a 2-week period, the second viewing session was undertaken. Prior to this, the teeth were randomized again to exclude the possibility of participants recalling their previous decisions on the first viewing. For this final viewing session, the coronal aspects of the teeth were obscured using black paper. Labels and arrows directed the observer to the root under consideration to ensure that there was no ambiguity as to which root was being examined. The viewing conditions were identical to those undertaken previously.

Sensitivity and specificity was calculated for each group of observers for both viewing sessions using the consensus diagnosis derived by the two dental radiologists. The resulting data was analysed using the SPSS PC+ system (SPSS Inc., Chicago, IL, USA, 2007). An ANOVA test with a Bonferroni correction was used to compare the frequencies of total correct interpretations for each group of observers during the first and the

second viewing sessions. Paired *t*-tests were used to compare differences in sensitivity and specificity for each group between the first and the second viewing. Ninety-five per cent confidence levels were set as the threshold for statistical significance. Finally, the date of graduation of each of the postgraduate students and clinical tutors was recorded as was their assessment of the effectiveness of their undergraduate radiological training in diagnosing apical pathosis.

Results

The postgraduate participants had graduation dates ranging from 1 to 17 years (mean 6.4 years) prior to the commencement of the study. For the clinical tutors, there was a wider range of graduation dates, ranging from 7 to 34 years with a mean of 17.7 years. Four of the clinical tutors and all of the postgraduate students stated that their undergraduate radiological training was adequate. The remaining three clinical tutors reported that their undergraduate radiological training was excellent. By contrast, the participating undergraduate students had completed their radiological training some 6 months prior to the commencement of the research study and each felt that their undergraduate radiological training was adequate.

When the crowns were masked, the undergraduate students had a significantly lower sensitivity ($P = 0.008$) when compared with the postgraduates and tutors. No significant differences were noted between the three groups of observers when the teeth were imaged in their entirety. During the first viewing, the proportions of undergraduate observers with 'true' scores ranged from 58.3% to 75% with a mean value of 65.5% (Table 1). Sensitivity and specificity for the undergraduate cohort during the first viewing session was 0.67 and 0.64 respectively (Table 2). During the second viewing session, with the crowns of the teeth masked, proportions of undergraduate observers with 'true' scores reduced to 61.3% overall, with a range of 50–66.7% (Table 1). For this session, sensitivity and specificity also reduced to 0.63 and 0.60 respectively (Table 2). During the first viewing, the proportions of postgraduate observers with the 'true' scores ranged from 37.5% to 83.3% with a mean value of 65.6% (Table 1). This increased to 78.7% (range 62.5–91.7%) for the second viewing (Table 1). The overall sensitivity and specificity for the postgraduate students was 0.59 and 0.72, respectively for the first viewing session rising to 0.79 for sensitivity and 0.78 for specificity during the second viewing session (Table 2). The increase in sensitivity by the postgraduate students for the second viewing, with the crowns of the teeth masked, was significant ($P = 0.037$). The clinical tutors, during the first viewing, recorded 'true' scores ranging from 66.7% to 79.2% with a mean value of 74.4% (Table 1). For the second viewing, the clinical tutors with 'true' scores ranged from 54.2% to 91.7%

Table 1 The percentage range of 'true' scores and the average percentage score for each of the participating groups for the first and second viewing sessions

	First viewing		Second viewing	
Groups	Proportions of observers with 'true' diagnosis (%)	Average score for group (max = 24)	Proportions of observers with 'true' diagnosis (%)	Average score for group (max = 24)
Undergraduates	58.3–75.0	15.71	50.0–66.7	14.71
Postgraduates	37.5–83.3	15.75	62.5–91.7	18.88
Clinical tutors	66.7–79.2	17.86	54.2–91.7	19.15

Table 2 Mean sensitivity and specificity for the first and second viewing for each group of participants with range of values

Participants	Viewing session	Sensitivity (mean)	Range	Specificity (mean)	Range
Undergraduates	First	0.67 (0.10)	0.50–0.75	0.64 (0.13)	0.50–0.83
	Second	0.63 (0.08)	0.50–0.75	0.60 (0.12)	0.50–0.75
Postgraduates	First	0.59 (0.18)	0.25–0.75	0.72 (0.19)	0.33–0.92
	Second	0.79 (0.09)	0.67–0.92	0.78 (0.16)	0.50–0.92
Clinical tutors	First	0.69 (0.14)	0.50–0.83	0.80 (0.08)	0.67–0.92
	Second	0.80 (0.13)	0.58–0.92	0.80 (0.18)	0.50–0.92

with a mean value of 79.8% (Table 1). The sensitivity of this group of observers increased from 0.69 during the first viewing to 0.80 for the second viewing. Specificity remained unchanged at 0.80 for both viewing sessions respectively.

When the teeth were unmasked, group 1 films (i.e. those exhibiting a normal periapical status with an accompanying minimal restoration present) had their apical status correctly recorded in 92.8% of cases by the clinical tutors (Table 3). This reduced by 2.3–90.5% of cases when the crown was masked. By comparison, the postgraduate students increased their score from 77.1% when viewing the unmasked image to 79.2% when the crown was masked (Table 3). For the undergraduates, there was no difference between the first and second viewings (59.5%). For those teeth with a minimal restoration and showing apical pathosis, both the clinical tutors and the postgraduate students recorded a 16.7% increase in the number of correct observations of the apical status when the crown of the tooth was masked (Table 3). By contrast, the undergraduates recorded a 23.8% reduction in the percentage of correct assessments of the apical status when viewing masked group 2 films (with pathosis and minimal restoration).

For group 3 films (normal periapical status but heavily restored), both the clinical tutors and postgraduate students recorded an increase in the number of correct observations of the apical status of teeth when the crowns were masked of 14.3% and 8.3%, respectively (Table 3). Group 4 radiographs (i.e. those with apical pathosis and also heavily restored) emerged as the only group of films in which each of the observer groups recorded an increase in the number of correct assessments when the coronal tooth tissue was masked. The postgraduates recorded the highest increase between the first and second viewing sessions with an 18.5% increase followed by the undergraduate group who recorded a 16.2% increase. By contrast, the clinical tutors recorded a more limited increase of 4.4% (Table 3).

Discussion

In a study on radiographic viewing conditions (Patel *et al.* 2000), masking of the crowns of teeth was undertaken to eliminate the possibility of the observer gaining any information which may have influenced their diagnosis about the periapical status of the tooth. Whilst the results of the study supported the routine use of ideal viewing conditions, it provided no information as to the influence of the crown on the observers' assessment of apical pathology. The present study was therefore devised to determine the influence of the status of the crown on radiological interpretation of the periapical tissue.

Inconsistency in radiographic interpretation between observers is a well-recognized problem (McCreery & Truelove 1991a). This study has shown that both experienced and inexperienced clinicians are influenced to varying degrees by either the restorative status of the tooth or the extent of caries in coronal tooth tissue when assessing the apical status. This research has also highlighted the greater diagnostic acumen of the experienced clinician compared with those with less clinical training. The latter is in line with the findings of a number of studies from both medical practice (Robinson 1997, Eng *et al.* 2000, Buchanan *et al.* 2004) and dental practice (Reit & Hollender 1983, Abdel-Wahab *et al.* 1984, McCaul *et al.* 2001). This study has also emphasized the importance of 'pattern recognition' in radiological interpretation, which allows the observer the ability to classify films with pathosis correctly or to accurately say that there is no pathosis (Ripley 1996).

A literature search found only one medical study that had employed masking (Tingberg *et al.* 2005). Tingberg *et al.* investigated the influence of masking irrelevant parts of the chest radiographs and those of the lumbar spine. Paradoxically, this study found a rise in inter-examiner variation as the method of masking profoundly affected the radiologists' normal visual and

Table 3 Percentage accuracy of 'true' observations of the apical status for each of the three groups of observers for the four categories of teeth during the first and second viewing sessions

	Normal with minimal restoration (%) (group 1)		With pathosis and minimal restorations (%) (group 2)		Normal and heavily restored (%) (group 3)		With pathosis and heavily restored (%) (group 4)	
Participants	First viewing	Second viewing	First viewing	Second viewing	First viewing	Second viewing	First viewing	Second viewing
Undergraduates	59.5	59.5	78.6	54.8	59.5	57.1	54.8	71.0
Postgraduates	77.1	79.2	60.4	77.1	66.7	75.0	62.5	81.0
Clinical tutors	92.8	90.5	59.5	76.2	66.7	81.0	78.6	83.0

interpretative search patterns. This resulted in the study being discontinued before completion. However, this was not the case in the present study.

It was noticeable that for the less experienced observer, the removal of the coronal tooth tissue status led to diagnostic uncertainty. McCreery & Truelove (1991b) noted that decision analysis involves the identification of all available choices and the potential outcomes of each choice. When the less experienced clinician was denied the visual prompt of the coronal aspects of the tooth, a proportion of the decision-making pathway was no longer available to them nor was the quantifiable experience of the more experienced clinician. However, as clinicians, they were still required to make a logical decision with only the radiological appearance of the periapical tissues to rely on. Masked group 4 teeth (i.e. those teeth heavily restored and with pathosis) was the only group in which the undergraduate students increased their score. It could be argued that the signs of apical pathosis may well have been more obvious on these heavily restored teeth and this fact, combined with masking, actually enhanced the presence of apical pathology even to the most inexperienced observers within the study. By contrast, the postgraduate students significantly increased their sensitivity during the second viewing when the crowns of the teeth were masked. This gives support to the hypothesis that experience confers more diagnostic ability, whilst masking eliminated any potentially influential restorative factors that might have distracted the observer from the logical process of pattern recognition of the radiological signs of apical pathosis.

This study can be criticized as the methodology relied upon 'expert-derived' diagnosis, as the 'gold standard' of a histopathological examination of the tissue to determine the presence or absence of pathology was not an option available to the researchers. However, the use of a complete clinical assessment from the patients' notes in the assessment of the periapical status of teeth has been previously used successfully by Bohay (2000). Bohay noted that the use of complete clinical records went some way to minimizing the risk of bias within the research study. Furthermore, this study employed ideal viewing conditions which have been shown to produce greater diagnostic yield and also improve the diagnostic accuracy of the observer (Patel *et al.* 2000). In addition, only one light-box was used in order to exclude the possibility of gross variation in light intensity, brightness and colour that might have occurred if multiple light boxes had been used.

Conclusion

The status of coronal tooth tissue has been shown to influence the radiological interpretative skill of the clinician to varying degrees. However, this study has shown that this effect is more noticeable when films are viewed by the more inexperienced clinician. As such, it may well be beneficial to provide more intensive radiology training earlier within the undergraduate curriculum in order to effectively consolidate radiological interpretative skills prior to graduation.

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