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Long-Term Validation Study of Bitewing Dental Radiographs for Forensic Identification

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ABSTRACT: The validity of dental bitewing radiographs for forensic identification, with time lapses between the antemortem and postmortem film of up to 30 years, was tested. The ability to match radiographs from the same subject was expressed using sensitivity and specificity statistics. Although the overall accuracy of the observers was extremely high, it was obvious that radiographs from the same individual, when separated by time intervals greater that 20 years, had significantly reduced accuracy.

KEYWORDS: forensic science, forensic, odontology, forensic dentistry, bitewing radiography, long-term validation, human identification

Recent validation studies have reported that dental bitewing (BW) radiographs are useful tools for forensic dental identification (1–4). Since these radiographs are frequently a part of dental records, they are commonly used by forensic odontologists. For dental identification, high degrees of accuracy in adult and children populations, even in cases where there have been minimal dental treatments, substantiates their use. However, it is not clear whether this high level of accuracy is maintained when a considerable time lapse exists between the antemortem film and the postmortem film.

Bitewing radiographs can be effective comparative evidence when used for dental identification because of the large amount of detailed information registered on the film. Anatomic features such as crown size and shape, pulpal anatomy, and the position and pattern of the crestal alveolar bone are useful comparative characteristics. In addition, and in many ways more important, are the changes caused by caries and its repair by dentists. Dental treatment results in unique and individually characteristic restorations, which for the most part are well depicted on BW radiographs. The odontologist considers all these anatomic, pathologic and artificial characteristics when making an assessment of antemortem and postmortem dental radiographs. There is both empirical and scientific support for the value of BW radiographs when there have been few changes to the dentition (1,2,4). However, when there is a substantial time lapse between the antemortem and postmortem radiographs, it is possible that some, or all these significant features could be degraded or lost. Untreated caries can lead to destruction of a considerable part of the crown and in some cases necessitates extraction. Although the radiopaque nature of metallic restorations often provides useful comparative features, in cases of heavily restored teeth these restorations may obscure important features such as pulpal anatomy. Where the antemortem film reveals deciduous teeth the postmortem film may be of little value if only permanent teeth are depicted. This situation is worse if, in the postmortem radiograph many restorations are found in bicuspids and first molars. This may obscure and remove from the comparison whatever cusp or pulpal anatomy was seen of the unerupted permanent teeth on the child's BW. Some indication of this effect has already been reported (4).

Although many people retain the same dentist for long periods, this is not so with a large part of the population. In Canada, 28% of the population visit a dentist less frequently than once per year (5). Regardless whether they seek out the same practitioner, these appointments may be separated by considerable time lapses. Immigration and an increasingly transient workforce also require changing dentists. When police investigators seek the last known dentist, they usually question the next of kin or friends who are not always aware of the most current dental care provider. Other factors may affect the retrieval of the most recent radiographs. Dentists may legally discard dental records after a specific nonactive period. In the Province of Ontario, Canada there is a statutory requirement that records must be kept for ten years after the last appointment (6). In addition, dental radiographs can be misfiled or degraded due to poor storage or inadequate processing. On rare occasions, the most recent dental records can be destroyed in the same event which caused the death of the individual to be identified (7). Even when the most current records are recovered, there still may be a considerable time lapse between the last antemortem radiograph and the postmortem record.

This is the third in a series of reports that explore the scientific validity of the BW radiograph for dental identification. The first paper (2) dealt with the subject in generalities while the second focused on the use of these films in the identification of children (4). The purpose of this research is to evaluate the validity of BW radiographs for dental identification where there is a considerable time lapse between the antemortem and the postmortem films and where there has been a range of intervening dental treatments, including replacement of restorations and extractions.

Materials and Methods

Radiographs for the study were selected from the dental records of a general dental practitioner in London, Ontario, Canada, as previously reported (2). The sample consisted of 400 bitewing radiographs placed in 100 matched (same patient) and 100 unmatched (different patient) pairs. The radiographs typified

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patients with both continuous and intermittent treatment over prolonged periods. Time spans between the simulated antemortem and postmortem radiographs ranged from four to thirty years. All radiographs were number 2 dental bitewing film and were of archival quality. Film speed (Type C and D) and manufacturers (Kodak and Dupont) were varied due to the long time frame. The earliest radiographs were taken from records dated 1955. The paired radiographs were mounted in modified paperboard radiograph mounts (Rinn Corporation #10-0156). The upper window of each mount was marked with the patient's initials and date of the antemortem radiograph. All matched and unmatched pairs were randomly mixed. The backs of the mounts were numbered sequentially to allow all observers to view the sample in the same sequence. The observers included a forensic dentist, an oral radiologist and a dental student who had completed one course in oral radiology.

The remainder of the method was conducted as previously reported, however, the observers kept a log of the time and number of radiographs viewed in each session. This provided an opportunity for analysis of when errors occurred. The fundamental object for the observers was to study each pair and to decide whether the radiographs were from the same or different individuals.

Statistical Methods

Sample size was calculated using the 93% accuracy determined in our previous validation study (2). Sensitivity, specificity and accuracy were used to interpret the data obtained from the six hundred decisions made by the observers.

Sensitivity is the ability of the observer to correctly choose matched pairs of radiographs. A correct choice in this group is a true positive (TP). An incorrect decision from the matched group is a false negative (FN). Sensitivity = TP/(TP + FN). Specificity is the ability of the observer to correctly identify unmatched pairs of radiographs. The correct identification of an unmatched pair is a true negative (TN). An incorrect identification is a false positive (FP). Specificity = TN/(TN + FP). Accuracy combines sensitivity and specificity and gives an overall success of the test. Accuracy = (TP + TN)/(TP + TN + FN + FP).

Results

The sensitivity and specificity achieved by each observer and the overall accuracy are displayed in Table 1. The average accuracy of 93% is the same as the previous study of adult bitewing radiographs over a shorter am\pm interval. Fig. 1 shows the distribution of FN errors. Approximately 69% of these errors were made when the time lapse extended beyond 20 years and almost 60% when the time lapse was greater than 25 years. Three observers made the same FN error in seven cases; all but one had time lapses greater than 19 years. It is not possible to calculate the rate of FP errors over time since the pairing of the non-matched radiographs was done artificially. In this study there were only two FP errors made by all observers. Figure 2 illustrates the FP errors (A&B), and two examples of FN errors (C&D).

TABLE 1—*Accuracy of primary dental identification in a simulated forensic identification with a time interval 4–30 years.*

Observer	Sensitivity	Specificity	Accuracy
1	.81	1.00	.91
2	.87	1.00	.94
3	.87	.98	.93

NOTE:—The observers' average accuracy of 93% is the same as the previous study of adult bitewing radiographs over a shorter am\pm interval.

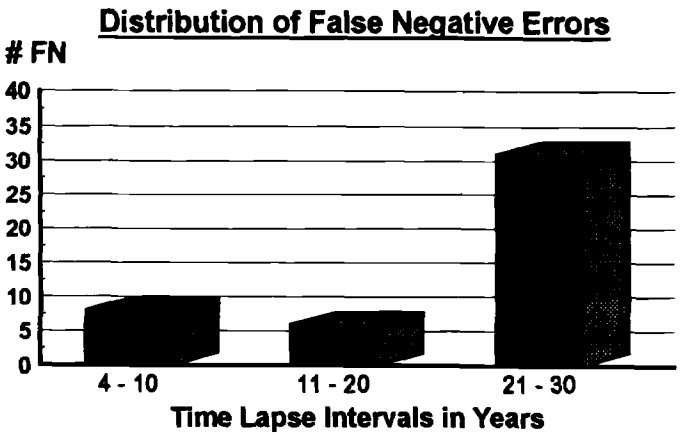

FIG. 1

Discussion

Previous validation studies of the accuracy of dental radiographs for identification purposes had intervals between antemortem and postmortem radiographs from a few months up to fifteen years (1–4). The interval between the simulated am\pm paired radiographs in a recent validation study of adult bitewing radiographs ranged from one to fifteen years, but there were few cases with intervals greater than four years (2).

The examples of FN errors shown in Fig. 2 were selected from a group incorrectly deemed not a match by all three observers. For most of the cases where all observers were unable to correctly make an identification, the time span between the am\pm radiographs was thirty years. A review of these films reveals significant regressive changes to the pulpal anatomy, loss of alveolar crestal bone, additional metallic restorations that obscured coronal anatomy and changes in tooth to tooth relationships as a result of drifting and tipping.

The law in Ontario requires that dental records be retained for a minimum of ten years after the dentist last sees a patient or two years following the death of the dentist. When minors or others incapable of making rational decisions are involved, records must be kept longer. The law apparently is concerned with issues involving negligence or malpractice without considering the legal issue of forensic identification. There have been suggestions that dental records should be kept indefinitely. If this advice is followed, there is greater likelihood that older radiographs will be available for forensic purposes in the future.

This study confirms the intuitive conclusion that the usefulness of dental BW radiographs decreases as the time between the am\pm radiographs increases. In our study, the false negative errors were infrequent (less than 10%) for each five-year interval until 25 years but increased significantly after 25 years. Of particular interest, the critical false positive error, was not a significant problem with the long-term radiographs. Two observers made no false identifications and one observer made two false identifications. These false positive occurred on the 58th and 164th observation and may have been due to fatigue from the large number of observations. No consultation was allowed in this study. The value of consultation and consensus in improving the accuracy of the

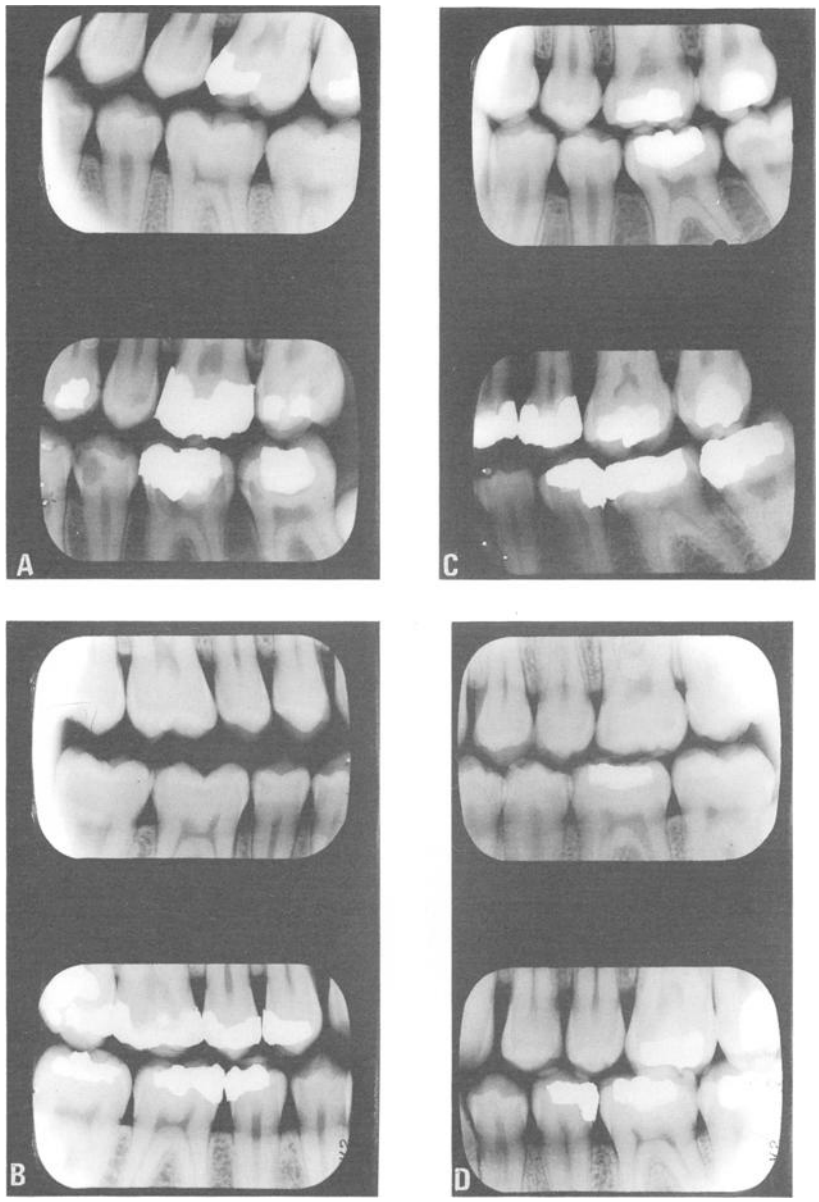

FIG. 2—*The AM/PM of bitewing pairs C and D are separated by 30 and 8 years respectively.*

BW comparison in forensic identification, although commonly accepted, needs further study.

The results of this study confirm both the empiric observation and the recently published scientific studies that BW radiographs have high validity for am\pm identification. This is apparently true over all age groups and a wide range of time intervals between the am\pm radiographs. There is ample anecdotal evidence that forensic dentists have successfully used radiographs that were made thirty or more years prior to death. Our study confirms the validity of using these films, but suggests the exercise of particular caution since both regressive and restorative changes may significantly interfere with the forensic dentists ability to correctly identify a true match.

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