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The Validity of Bitewing Radiographs for the Dental Identification of Children

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ABSTRACT: Visual comparison of antemortem and postmortem bitewing radiographs of children and adolescents were made by observers with a range of experience using an established protocol. There was no statistically significant difference between the sensitivity, specificity and accuracy of the test results between children (6–9 years) and adolescents (8–11 years). The average sensitivity, specificity and accuracy of the pooled results for children was marginally less than for adults, but the difference was not statistically significant.

KEYWORDS: forensic science, odontology, forensic dentistry, human identification, children, bitewing, validation

Bitewing radiographs are routinely used by dentists to disclose caries between teeth and around the margins of existing restorations. For patients of all ages, they are the most frequently made radiographs in dental practice. It is likely that bitewing (BW) radiographs make up a greater proportion of the total radiographs used in pediatric dentistry than in dentistry for the adult population. As the comparison of antemortem and postmortem radiographs is a mainstay of forensic dentistry, the forensic odontologist is frequently called upon to evaluate the images recorded on BW when attempting to determine the identification of an unknown. Recently, the validity of bitewing radiographs in making identifications in an adult population has been shown to have both high sensitivity and specificity [*1*].

Visual comparison of radiographs relies on the depiction of significant points such as unique anatomy, metallic restorations, developmental anomalies and disease patterns. These characteristics appear in the BW radiographs of both adults and children. In addition, some features peculiar to children may assist or interfere with the comparison of antemortem and postmortem radiographs. An obvious factor is the smaller film size used for BW of children. Restorative dental treatments for children rarely include complex restorations such as crowns or fixed bridges, which are often seen in adults. Intracoronal treatments such as pins, posts and root canal therapy are not as common as that observed in adults. Also, there may be less tooth structure to use in the comparison process. The roots of deciduous teeth are naturally shorter than permanent teeth and are further shortened by resorption during the eruption process. Moreover, permanent tooth eruption results in the shedding of deciduous teeth, which may have had characteristic restorations. The pattern of bone loss associated with periodontal disease and the detail of the interdental bone may be useful when assessing adult BW radiographs. However, in children periodontal disease, with accompanying bone loss, is a rare event. Finally, there has been a considerable decrease in the caries rate of children in most technically advanced countries. It has been shown in some populations that approximately 60% of children will lose their deciduous teeth without having a restoration; thus, posing additional problems for the forensic dentist [*2*]. Borman et al. [*3*] and MacLean et al. [*1*] have demonstrated that BW radiographs are valid for making identifications within the adult population, even when no or few restorations are present. Currently there are no data to support the validity of using bitewing radiographs for the forensic identification of children.

The purpose of this study was to test whether observers could match antemortem and postmortem radiographs in two subsets of children. One set consisted of children whose antemortem and postmortem radiographs were made before the loss of deciduous teeth (6–9 years). The second subset was composed of children whose antemortem radiographs were taken prior to the loss of deciduous teeth and the postmortem after the eruption of one or more permanent bicuspids (8–11 years).

Materials and Methods

The radiographs for the two samples were selected from the paediatric dental records at the Faculty of Dentistry, The University of Western Ontario, London, Canada, in a manner previously reported [*1*]. Each sample consisted of 400 BW radiographs which were paired in 100 matched (same patient) and 100 unmatched (different patients) groups. The radiographs were representative of a paediatric population having healthy, minimally restored dentitions. Radiographs of teeth with dental restorations were included in the sample only if these features did not help in the identification.

Inclusion criteria for the younger sample required that the first permanent molars be unerupted in the antemortem radiograph. The older sample had the first permanent molar erupted but were still in the mixed dentition stage. This criteria limited the time between antemortem and postmortem to five years or less. Due to the variety of patients and operators, the sample was composed of a mixture of film sizes (#0, 1 and 2). The radiographs were mounted in modified paperboard mounts (Rinn Corporation #10-0156, #10-0106, #10-0102) with the front of the mounts marked to indicate

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correct orientation for viewing and the back of the mounts numbered to allow all observers to view the samples in the same sequence. Matched and unmatched pairs of radiographs were randomly mixed.

Three of the four observers participated in both portions of this study. The observers included a forensic dentist, a periodontist, a paediatric dentist, an orthodontist and a dental student with one course in oral radiology. The remainder of the method was conducted in a manner previously reported [*1*] but the observers kept a log of the time and numbers of radiographs viewed in each session.

Statistical Methods

Sample size was calculated using the 93% accuracy determined in a previous validation study of adult bitewing radiographs [*4*]. Sensitivity, specificity and accuracy proportions were used to interpret the data for both groups of children. In this context, sensitivity is the ability of the observer to correctly choose matched pairs of radiographs. Specificity is the ability of the observer to correctly identify unmatched pairs of radiographs. Accuracy combines sensitivity and specificity, and is a measure of the overall success of the test. In the matched group a correct choice is a true positive (TP), whereas an incorrect decision is a false negative (FN). The correct choice in the unmatched group is a true negative (TN), while an incorrect choice is a false positive (FP). Confidence intervals of 95% were calculated for all proportions. A one-way analysis of variance (ANOVA) with the Tukey range test was used to determine statistical significance between group data. A probability value of $P < 0.05$ was considered statistically significant.

Results

The average sensitivity, specificity, and accuracy of all observers for the child and adolescent sample is recorded in Table 1; similar data for an adult sample [*1*] are included for comparison. There was no statistically significant difference between any of these groups. Two observers made no critical FP errors in the child sample whereas one observer made no critical FP errors in the adolescent sample. The observer with the greatest number of FP had the fewest non-critical FN errors. There were minimal common FP errors amongst the observers in the child sample (2/49) and no common FP errors (0/12) in the adolescent identification. Many common FN errors were made in both groups. There was no obvious connection between the time required to do the identifications and the number of errors made. There was also no trend for errors to occur late in the observation sessions.

Samples of FN and FP errors are shown in Fig. 1A and B. The FN example taken from the child sample was incorrectly declared a nonmatch by 3 of 4 observers. The FP example from the adolescent sample was incorrectly declared a match by one observer.

TABLE 1—*Accuracy of comparison of matched and non-matched BW radiographs of children and adults.*

GROUP	Average Sensitivity	Average Specificity	Average Accuracy	Overall Accuracy
Child	.86	.88	.87	.88
Adolescent	.77	.97	.88	
Adult [*1*]	.89	.97	.93	

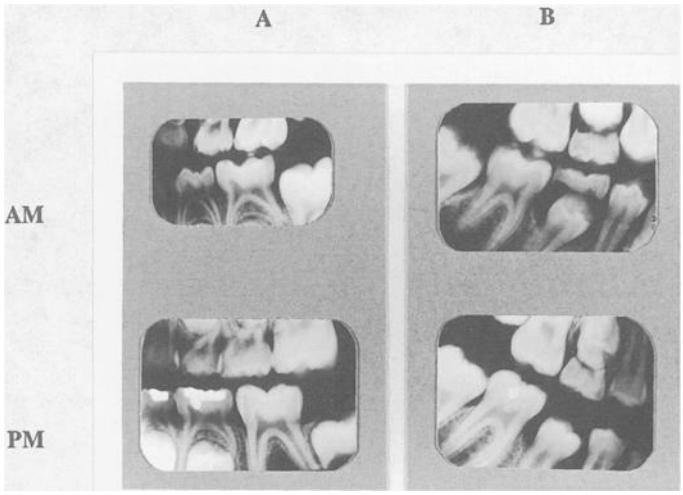

FIG. 1—*The pair of radiographs marked* A *is an example of an FN error taken from the children's group. The pair of radiographs marked* B *is an example of an FP error taken from the adolescent group.*

Discussion

Recent studies have confirmed that BW radiographs have high validity when used for forensic dental identification [*1,3*]. The radiographs used in these studies were selected from patients who represented both a wide range of ages and a variety of dental treatment. Although examiners could match antemortem and postmortem BW radiographs with high sensitivity and specificity, even in patients with minimal dental treatment, it is not evident that this result was consistent over the entire range of ages. Of particular concern was the value of antemortem and postmortem BW of children in the deciduous and transitional dentitions. A variety of factors would appear to adversely affect the ability of examiners to make correct matches in young children. However, our results suggest that in spite of fewer restorations and the shedding of deciduous teeth, the sensitivity and specificity remained quite high for children between six and eleven years of age. Furthermore, this study did not detect any significant difference between children with deciduous teeth (6–9 years) and children in the transitional dentition (8–11 years). Although the average sensitivity, specificity and accuracy of the pooled results for children was marginally less than that observed in an adult population [*1*], this difference was not statistically significant. Observers who completed both the adult and the child studies reported that the comparison of the childrens' radiographs was a more difficult task.

It might be explained from these data that individual judgment or professional experience may have had an influence on the approach each examiner used when completing the test. For some, the FP (misidentification) may have been regarded as a critical error and therefore, the examiners who allowed for this perhaps required more evidence to support a match. These observers would generally have lower sensitivity but both high specificity and accuracy i.e., they tried to make few FP errors at the expense of perhaps not making as many true identifications of matches. These examiners rarely made false matches of nonmatches.

In the adolescent data there appeared to be a trend to decreased sensitivity when time lapses between the antemortem and postmortem radiographs reached approximately 60 months. This observation perhaps can be explained on the basis that less information was available for comparison on these radiographs. This group of

patients had lost most, if not all, of their deciduous teeth and the permanent bicuspids were in the process of erupting. There were few restorations in the postmortem films and where restorations were present, they often could not be compared to the antemortem film since the permanent bicuspids were unerupted. This effect could also occur in the adult dentition in cases where many teeth are lost between the time when the antemortem and the postmortem films were made. The validity of adult antemortem and postmortem dental radiographs separated by long time lapses is currently under investigation.

Does collaboration improve the accuracy of the method? It is not common for forensic dentists to confer with colleagues in single identification cases; however it is the recommended protocol in mass disasters that all identifications be reviewed by a team member. Although the results of our study indicate that there is high validity working independently, could this be improved by consensus? Using a series of 30 matched and one nonmatched AM/PM BW of adults with a time interval of one to several years, Ekstrom et al. [5] reported that forensic dentists acting independently had an error rate that ranged from 0–35.5%, with an average error of 3.5%. Most of these errors were made on cases where there was no restorative dental treatment. The authors concluded that a second opinion should be obtained before making final confirmation. Further studies to test this hypothesis should be undertaken.

Artificial protocols have been used for these initial validity studies. The question of the practical validity of BW radiographs for forensic identification and in particular, mass disasters, should be assessed by designing a test that more closely resembles an actual event. These investigations are underway. Currently, all features of each BW radiograph are visually examined and compared. It is unknown whether certain features are more significant in the analytical process.

Advances in computer manipulation of radiographic images give promise of additional benefit to forensic dentists. Wood et al. [6] have shown that digitization and computerized cut and paste techniques can be applied to small areas of periapical dental radiographs to assist in the visual comparison. Wenzel and Andersen [7] have explored the use of subtraction radiography in the comparison of BW radiographs of children with no or few restorations.

The combined value of this study with previous reports [1,3,5] gives scientific support to the validity of using antemortem and postmortem BW radiographs for dental identification of all age groups.

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