

Panoramic Imaging as a Tool of Identification in Forensic Odontology

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Abstract

Introduction: Ante-mortem (AM) post mortem (PM) Comparison of clinically used dental radiographs is a classical method for forensic dental identification. An intraoral periapical radiograph (IOPA) is the most common tool used for investigation, evaluation and monitoring of dental disease progression. Panoramic radiograph or Orthopantomograph (OPG) is the most commonly preferred extra-oral dental radiograph by dentists and it also provides a wide coverage of both the jaws and teeth. Few studies offered to assess OPGs as a tool of identification in forensic odontology. **Aims and Objectives:** Verify the usefulness of panoramic radiograph as a tool for identification by planning a simulated ante-mortem (AM) and post-mortem (PM) panoramic radiographic comparison. The objective of this study was to check whether OPGs can be an effective tool of identification in the hands of a common dental practitioner. **Materials and Methods:** 50 individuals were enrolled for the study, age group of 17 to 25 who already underwent panoramic imaging. After taking consent another radiograph was taken at interval of 4 years. 100 pairs of matched and unmatched radiographs were generated and each of the 5 investigators was provided with a set of 20 paired radiographs and were asked to report positive and negative matching according to their observation. **Results:** Results provided by investigators revealed 66/100 positively matched and 34/100 negatively matched records. Accuracy, Sensitivity and Specificity were 95%, 96% and 91% respectively. **Conclusion:** Panoramic radiographs have been shown to be an excellent tool in forensic identification in this study in an age group of 17-25.

Keywords: Ante-mortem; Post-mortem; Panoramic; Orthopantomograph; Identification.

Introduction

Identification of individual by utilization of dental records has been dated way back to 49 A.D.[1] Since then evolution of forensic odontology has played a significant role in identification of unknown bodies. Forensic odontological examination is the primary means of identification in situations where

exposure, time elapsed after death and destruction of the body (fire, explosion, etc.) has made other means of identification impossible. Currently there are three types of personal identification that uses teeth, jaws and orofacial structures. These are comparative dental identification, reconstructive postmortem dental profiling and DNA profiling.[1] Comparative dental identification includes comparison of ante-mortem (AM) and post-mortem (PM) intra-oral and extra-oral radiographs, clinical photographs, study casts and dental prostheses to identify human remains. Imaging techniques are a powerful tool in

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forensic sciences which have been used extensively in dental identification. Teeth unlike other body structures are highly resistant to decomposition and are not easily destroyed. In victims where there is complete decomposition, radiographs may be only available biometric method.

AM-PM Comparison of clinically used dental radiographs is a classical method for forensic dental identification. An intraoral periapical radiograph (IOPA) is the most common tool used for investigation, evaluation and monitoring of dental disease progression. Few studies have undertaken the task of assessing IOPA radiographs for the purpose of forensic identification. In one such study Santoro *V et al* found 3% false negative and 2% false positive results using IOPA radiographs.[2] In a similar study by Balagopal S the accuracy rate decreased by 81.6% when time interval increased by 3 years.[3] Sholl and Moody found that the accuracy of dental radiographic identification was good but there was difference in result among forensic odontologist, recent dental graduates and dental hygienist.[4] Odontologists were more accurate than the others. Unfortunately, this study wasn't conducted on large sample which limits its value. Bitewing is another dental radiograph which has shown accuracy of 93% in dental identification.[5] This accuracy decreased when time interval between AM-PM radiographs increased.[6] Limited information provided by these intra-oral radiographs can be one of the problems for diverse result.

Panoramic radiograph or Orthopantomograph (OPG) is the most commonly preferred extra-oral dental radiograph by dentists and it also provides a wide coverage of both the jaws and teeth. OPG expands the spectrum of forensic radiology for the individual case and can also offers a reliable aid for victim identification in the wake of mass disasters, aircraft crashes and terrorist attacks, where a large number of bodies have to be identified under great pressure. In a reported case the male thought to be the son was identified from an ante-mortem

panoramic X-ray film provided by the family dentist, which matched every significant detail in the body.[7]

The topic has not got the kind of attention as it requires and there are very few studies offered to assess OPGs as a tool of identification in forensic odontology.

Hence a study was undertaken with an aim to verify the usefulness of panoramic radiograph as a tool for identification by planning a simulated ante-mortem (AM) and post-mortem (PM) panoramic radiographic comparison. The objective of this study was to check whether OPGs can be an effective tool of identification in the hands of a common dental practitioner.

Materials and Methods

The present study was conducted in Department of Oral Medicine and Radiology, Subharti dental College, Meerut. 50 students who already had a panoramic radiographic examination done in 2005 when they enrolled for graduation program were approached to participate in the study. These OPGs served as a simulated AM radiograph. After taking a proper consent from all the students and taking clearance from the ethical committee of the institution another panoramic radiograph at an interval of 4 years was performed for the same 50 students which served as simulated PM radiographs. Five investigators who are post graduate teachers in the department of Oral Medicine and Radiology, Oral Surgery and Periodontics were selected for the study. 100 pairs of matched and unmatched radiographs were generated and each investigator was provided with a set of 20 paired radiographs. Simulated AM radiographs were performed using Villa Rotograph machine of 75KVp and 7 mA exposure factor and simulated PM radiographs were performed using Vatech machine of 68 KVp and 6 mA. The radiographs were performed by using standard protocol for radiation protection

Table 1: Four Way Contingency Table

True Positive (TP)	Right selection of correct match.
True Negative (TN)	Right selection of incorrect match.
False Negative (FN)	Rejecting a correct match.
False Positive (FP)	Incorrect selection of incorrect match.

Table 2: Results by Investigator

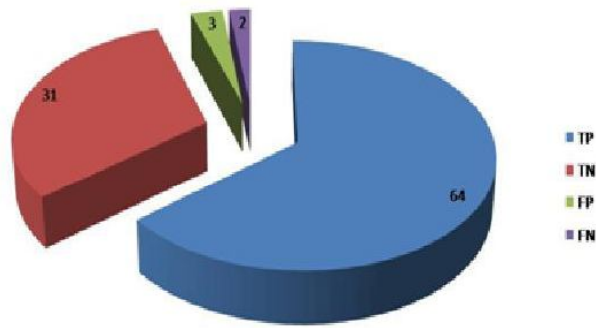
TRUE POSITIVE (TP)	64/100
TRUE NEGATIVE (TN)	31/100
FALSE POSITIVE (FP)	03/100
FALSE NEGATIVE (FN)	02/100

given International Commission of Radiological protection.

Since the former radiographs were conventional, they were digitalized using a 14 mega pixel camera (pixel size= 256 x 256). Radiographic Image was tiled side by side on Microsoft power point slides for easy and convenient comparison for the investigators (Fig 1). Each investigator was provided with 20 pairs of radiograph on their lap tops (standard configuration) and were asked to

report positive or negative matching according to their observations for each of the given pair. The option of 'not sure' was not given to the investigator. Cross-consultations were not permitted. The result provided by investigators was subjected to a four way contingency table (Table 1) and statistical analysis was performed by calculating the sensitivity, specificity and accuracy.

Fig 1: Simulated Ante-mortem (AM)**Fig 2: Post-mortem Panoramic Radiographs (OPG)**

Fig 3: Pie Chart Showing Results

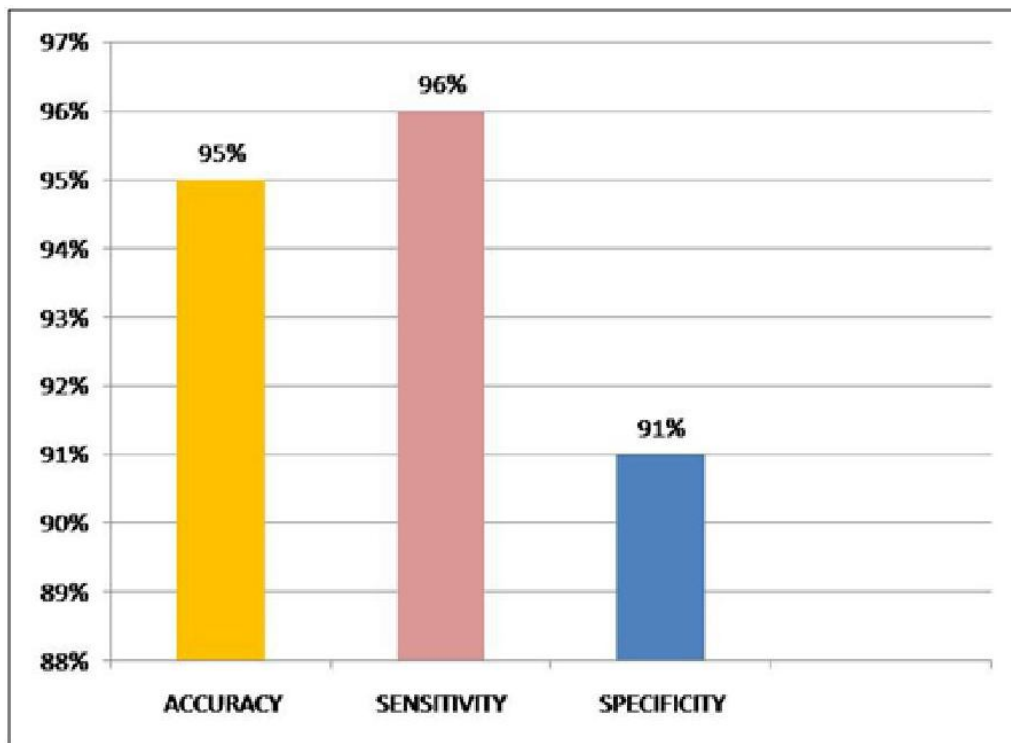
Results

Results provided by investigators revealed 66/100 positively matched and 34/100 negatively matched records (Fig 2 and Table 2). Accuracy, Sensitivity and Specificity were 95%, 96% and 91% respectively (Fig 3).

Discussion

Comparison of post-mortem and ante-mortem dental radiographic films or digital images is a common procedure for establishing

identity of human remains. Well suited situations for comparison of AM and PM radiographs can be used in mass disaster or personal identification in court of law. Several dental radiographs have been evaluated to serve for identification purpose in forensic science. A study conducted on bitewing radiographs in simulated forensic radiographs has yielded an accuracy of 93%. [5] Similar study conducted by Balagopal S *et al* with IOPA radiographs showed an accuracy of 81.6%. [3] Use of panoramic radiographs to serve for the purpose of forensic identification was first reported by Schwartz S *et al* in 1977. [8] In a comparative study conducted by Lee SS *et al* OPGs were described as an excellent means of identification not only based on the full dentition but also when only the posterior teeth are available. [9] Although dental identification rate for Tsunami victims in Phuket ranges about 80% [10], it is less frequently presented in court of law than bite mark identification. [11] Hence it is essential to make the agencies, requesting the services of odontologist, aware of accuracy of the dental radiographs which can serve the purpose of

Fig 4: Bar Chart showing Calculated Result in Percentage(%)

forensic identification. OPGs despite showing excellent results have not yet been established as an aid in forensic identification in the court of law.

In our preliminary effort to assess the validity of OPGs for purpose of identification, we comprised our sample to 50 individual. The difference in accuracy was found when AM-PM IOPA radiographs were separated by 3 years[3]; hence a time interval of 4 years was decided in our study. A 100% success rate of matching radiographs was reported in a study conducted by Sholl if the examiner had formal training or had an extensive practical experience with radiographs than those with formal training but little practical experience.[4] Formal training is highly desirable but no substitute for practical experience. Hence senior oral radiologist, oral surgeons and periodontist who were also post graduate teachers were selected for the present study because of their better experience with OPGs in their day to day professional life.

Presence of restoration, prostheses, abnormal root and crown anatomy third molar pattern and endodontic treatment contributes unique points for discrimination. But over the past few years preventive dental treatment has reduced caries incidence and thereby rendered dental identification in caries free individuals difficult.[12] OPGs can show numerous individual structural and anatomical characteristics serving better in these situations. OPGs were shown to be an excellent identification modality in deciduous and permanent age group however still lacking in its accuracy in mixed dentition period and complete edentulous patient.[13,14] Unfortunately there is still very less data available to draw any final conclusion. Our study was limited to an age group of 17 to 25 years to check the efficacy of OPGs in this particular age group.

Our study showed a high sensitivity and specificity rate than those which were done using intra oral radiographs or cropped images showing restricted information.[3,15] Concomitantly the accuracy rate shown in our

study was higher than the accuracy shown by forensic odontologist using digitized intra oral radiographs.[16] This may be due to fact that OPGs enables visualization of wider structures of the jaws and related areas on a single radiograph.

Not only the results of our study are quite encouraging with an accuracy of 95% it also shows that Identification based on panoramic information is an efficient, reliable and rapid procedure. The results of our study were in accordance with Lee SS *et al* who found 99.92% accuracy for full dentition.[9]

Our study further enlightens the fact that OPG has a definite advantage over IOPAs in the field of forensic identification as it provides more information, covers wide area of maxillofacial region and it is easier to store a single OPG than several IOPAs.

The task of identifying human remains based on dental comparisons of PM and AM radiographs is labor-intensive, subjective, and has several drawbacks, including: inherently poor image quality, difficulty matching the viewing angles in PM radiographs to those taken AM, and the fact that the state of the dental remains may entirely preclude the possibility of obtaining certain types of PM radiographs. Records maintenance is legally mandatory in American and European countries but the rules are not clear in India.[17] Under Article 51 A(h) of the Constitution of India, there is a moral obligation on the doctor, and a legal duty, to maintain and preserve medical, medico-legal, and legal documents in the best interests of social and professional justice.[18] According to recent surveys the practice of dental record maintenance is surprisingly low in two different states of India. [19,20] Another problem is lack of employment of clinical radiographs in dental practice. In another survey, recently graduated dental practitioners more commonly use diagnostic radiography than those with a longer time from graduation.[21] Also because of radiation hazards it has frequently been argued that only those patients should be examined radiographically who presents

definite clinical evidence of disease. "The Selection of Patients for X-Ray Examination" developed in 1987 by a panel of dental experts convened by the Center for Devices and Radiological Health of the U.S. Food and Drug Administration (FDA) and endorsed by the American Dental Association recommends a full mouth intraoral or panoramic radiographic examination for new edentulous patients. But in contrast European Guidelines on Radiation Protection in Dental Radiology doesn't recommend radiographic examination in case of healthy patients.[22] OPGs have been described as an effective substitute for full mouth IOPAs.[23] Use of OPGs reduces radiation dose by 40-50% considering that the dose from a panoramic radiograph approximately corresponds to 2-4 intraoral radiographs.[24] This dose can further be reduced up to 25% by using medium intensifying screens, digital panoramic images and rectangular collimators.[25]

Producing a post mortem panoramic dental radiograph can be a difficult task for an investigator. Several techniques have been described for taking post mortem OPG. Resection of the jaws, when permitted, significantly simplifies the postmortem radiographic technique. When producing an actual postmortem OPG from a dry skull, stabilization of the specimen for exposure by the moving beam source may be accomplished simply by placing the specimen upside down on an anthropologist's skull ring. Image "burnout" in the anterior segment, which results from absence of the tissues of the neck, may be avoided by appropriate placement of radiodense objects such as "zippered" plastic bags filled with water or other fluid material, freezer gel packs, or a block of self-polymerizing acrylic.[26] These methods may increase future postmortem dental radiography efficiency. However in a mass disaster scenario where a large number of bodies are to be examined, a portable panoramic radiographic machine can be used. A similar apparatus is used by Yamaguchi *T et al* and successfully identified twelve out of fourteen unidentified human corpses whose AM OPGs were available.[27] This method is

not time-consuming and also has the advantage of allowing dental treatment to be examined extra-orally in cases where it is difficult to open the mouth of the corpse. But these apparatus are still not widely available.

Innumerable variations of digital radiology techniques can be found in literature. These methods comprise of 1. Radiographic image digitization with scanner or video camera or directly from X ray system 2. Images processing through appropriate software allow image superimposition, interposition and subtraction. These modern techniques though allow accurate analysis, but also require validation of radiographs used for identification.

The aim of this study was to check the validity of OPGs in forensic identification and not to emphasize it's over use in day to day practice. The diagnostic capability of IOPAs cannot be neglected and resolution is better than OPGs if taken with proper standard procedure. This study highlights the under use of OPGs in dentistry and its utilization in field of forensic identification. The study also highlights the requirement of storing radiographic records under standard conditions so that it may be used as future ante-mortem records if required.

However, there are few limitations which cannot be assessed in our study which are efficacy of OPGs in children and adolescents who will have undergone none or very little dental treatment, edentulous persons and increased time frame between Ante-mortem and Post-mortem radiographs which tends to complicate the comparison. In our opinion, AM OPGs can also serve as a radiograph for comparison for PM IOPAs or bitewing radiographs and vice versa, but the comparison still remains to be validated.

Although identification of an individual of misfortune is frequently accomplished via comparison of ante mortem and post mortem radiographs but when dental radiographs are unavailable or of poor quality, the dentist may have to rely on other evidence such as study models, head and neck radiographs and anthropological examination results.

Conclusion

In this study, panoramic radiographs have been shown to be an excellent tool in forensic identification in an age group of 17-25. It has a decided edge over a single IOPA for identification. Hence it is recommended as a screening radiograph where more than one IOPA are required and sharper and finer details provided by IOPAs do not affect the treatment efficacy. It can double up as a radiographic ante-mortem record. A regular dental practitioner with no formal training in forensic Odontology but sufficient experience with panoramic radiography can also play an important role in identification. However future studies are required in this field to further validate the use of OPGs in the field of forensic Odontology and overcome the limitations of this study.

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