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ORIGINAL RESEARCH

The Role of Digital Dental Radiography in Private Dental Clinic in Kirkuk, Iraq: Opportunities and Barriers in Disaster Victims Identification.

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KEYWORDS

Forensic Odontology; Digital Dental Radiography; Antemortem Record

ABSTRACT

Evaluating the count of X-rays in private dental clinics using extraoral digital X-ray in Kirkuk, Iraq, and its role in mass disasters—natural or man-made—assesses opportunities and barriers for use as antemortem data, especially in situations where other identification methods are impossible, excluded, or costly. The success of the identification process depends on the availability of well-preserved antemortem data and accessibility to that data. Three private dental centers in Kirkuk (Alpha1, Alpha2, Panoramic) were selected according to criteria such as use of the same digital X-ray equipment, availability of archived dental records, and consent for participation and site access.

Data was collected from 2022 to 2024: only Alpha1 center was operational from August 1, 2022. Scan counts were 391, 305, and 345 annually, with steady population growth (1.05M → 1.10M). By 2025, in addition to Alpha1, Alpha2 and Panoramic centres were operating. Data collected until May 1, 2025, showed scan records reaching 1,668 — a 383% increase from 2024. There was a positive percentage change. The cumulative total number of scans reached 2,709. The cumulative percentage was 0.245 compared to the city center population of 1,128,000. Limitations of this study include a small sample size, lack of assessment of actual performance in a real disaster victim identification event, and the early start date of Alpha2 and Panoramic centres, so their data reflect only the initial implementation phase.

The total number of X-rays represents a reference that can be used as antemortem data for disaster victim identification, especially in Kirkuk, Iraq. Availability of medical imaging infrastructure can directly and rapidly increase the amount of stored data and service provision, which is a vital resource during mass casualty events requiring disaster victim identification.

1. INTRODUCTION

The word "forensic" comes from the Latin forense, meaning "public," "forum," or "marketplace," where legal issues were discussed [1]. Forensic odontology is a branch of dentistry that deals with handling, analyzing, and presenting dental findings for justice [2]. Dental identification is a valuable forensic method because of the many qualitative and quantitative traits of teeth. Its benefits include low financial and technological requirements and the simplicity of using such resources. In situations like fires, mass graves, aircraft accidents, or natural disasters such as floods and avalanches, where teeth may be the only retained parts of a human body, dental identification is extremely helpful [3]. Because they can withstand taphonomic processes and destruction for a long time, even under chemical and temperature variations, the maxillofacial bones and teeth are among the toughest structures in the human body [4].

Globally, forensic odontology and dental records are widely acknowledged for their use in legal and medical systems. Dental records are a vital resource for human identification and customized patient care, particularly during mass disasters and in a variety of legal contexts, including bite mark analysis and age estimation [5]. Forensic odontology, which compares antemortem and postmortem dental records, is a challenging yet essential method for victim identification, particularly in mass disasters [6].

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The quantity and quality of antemortem dental records largely determine how much forensic odontology can contribute to the identification process in a multi-fatality incident [7]. High-quality dental records are a necessary component of patient care [8], but not every nation has strict regulations regarding the documentation of dental treatment and the retention of dental records. A dental comparison may be hindered, particularly in developing nations, by the frequent absence of good records [9]. Forensic odontology can identify roughly 60% of victims when high-quality antemortem data are available, and it can help identify another 30% of victims when used in conjunction with other identifying techniques [10]. Dental documentation, which is used in the majority of these procedures, serves as a source of information about a person's antemortem dental health. It includes their medical history, written consent, intraoral and extraoral X-rays, photos, dental casts, and dental records with a status chart [11]. Dental radiographs, which are essential to forensic sciences, are among the most often used antemortem evidence for human identification [12].

Over the past few decades, there has been a steady and notable increase in the development of technology and its applications in the field of forensics. These advancements have made odontology's ability to assist in victim identification—in terms of speed, accuracy, and sensitivity—much more crucial than before [13,14]. Through dental inspection, which may include computed tomography (CT) scanning, three-dimensional virtual modeling, and physical and radiographic evaluation of the teeth and paradental structures, a victim's postmortem dental profile is created. An antemortem profile, created from a missing person's dental records which may include written treatment records, photographs, three-dimensional datasets, tooth casts, or other dental materials that can assist in identifying a person, is then compared to this postmortem profile [15]. With the absence basic antemortem data in Iraq, this study aims to assess the opportunities and barrier to apply the stored x-ray scan in digital dental x-ray in private clinic as antemortem data reference in disaster victim identification.

2. METHODOLOGY

The applied criteria to select clinics included the use of the same digital X-ray equipment, the availability of archived dental records, and consent for participation and site access. Three private dental centers in Kirkuk, all of which had installed digital dental X-ray systems, were selected for the study; other centers were excluded either because they were outside the specified geographic area or because they declined to participate. Center A (Alpha Digital) has been operational since August 1, 2022, while both Center B (Alpha2 Digital) and Center C (Panoramic Digital) began operations on January 1, 2025.

All three centers utilize the same company’s extraoral digital dental radiography product—specifically, the MYRAY Hyperion X5, which employs IRYS software with features such as automatic sensor and collimator alignment, ultra-high sensitivity in both three-dimensional and two-dimensional modes, and an adjustable, ergonomic head support. The system offers multi-field views ranging from 6x6 to 10x10 cm and provides fast, safe scans in just 6.4 seconds. Storage capacity varies with the field of view: for an image size of 10x8, capacity is 495 MB, while for 13x16 it is 820 MB.

Figure 1. extra oral digital dental radiograph

Ethical consideration

Before data collection began, ethical approval for the study was obtained from the Research Ethics Committee of the Kirkuk Health Directorate. Written informed consent was secured from the dentist owners of each participating clinic after the study’s

purpose, procedures, data management practices, and the voluntary aspect of participation were fully explained. This consent granted permission to access aggregate, anonymized service records. Throughout the study, patient data were anonymized and handled in accordance with applicable privacy and confidentiality regulations.

Data analysis

This research employed a retrospective cross-sectional study design, including quantitative data on the number and count of archived X-rays. Qualitative data from interviews with center owners were subjected to thematic analysis to assess centers' preparedness, defined as the presence of a secure digital archiving system for patient dental X-rays, a formal protocol for data sharing with forensic teams, and a designated staff member responsible for record retrieval during emergencies.
Awareness measures the knowledge and understanding held by clinic staff (dentists, hygienists, administrators) regarding their role and the importance of digital dental records in disaster victim identification (DVI). It encompasses their understanding of the forensic value of their records, the legal and ethical considerations of sharing patient data, and their familiarity with the clinic's preparedness plan for DVI practices.
The total number of patients receiving CBCT or panoramic X-rays was gathered from the three participating centers. X-rays are retrieved by the person in charge using a special code for data protection. The images are high-resolution and stored in internal memory, saved with basic patient information (name, age, date, X-ray type). Data were extracted from the start time of each X-ray center until May 1, 2025. Population numbers in Kirkuk city center were obtained from the Kirkuk election commission.

3. RESULTS

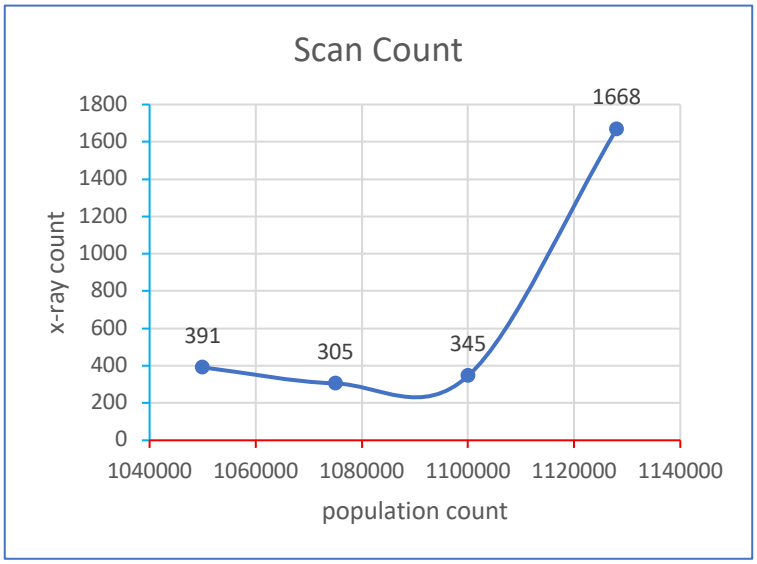
The data acquired show the annual total number of digital X-ray scans in relation to the city's population, providing insights on the spread of digital dental imaging and its potential implications for forensic identification. Table 1 summarizes the annual population, total X-ray scan count, the percentage of X-rays relative to the annual population, and the cumulative percentage over the study period.
As shown in Table 1, the population of Kirkuk city centre has steadily increased from 1,050,000 in 2022 to 1,128,000 in 2025. Concurrently, the number of digital X-ray scans acquired annually has shown fluctuations, with a notable rise in the final year of the study.

Year	Population Count	Scan Count	Percentage	Cumulative Percentage
2022	1050000	391	0.037%	0.037%
2023	1075000	305	0.028%	0.066%
2024	1100000	345	0.031%	0.097%
2025	1128000	1668	0.148%	0.245%

Table 1. Annual Dental X-Ray Scans Relative to Population Growth (2022–2025)

In 2022, with the Alpha Digital X-ray center operating for part of the year, 391 X-ray scans were recorded, representing 0.037% of the total population. The cumulative percentage for this initial year stood at 0.037%.
In 2023, while the population increased, the X-ray scan count slightly decreased to 305, resulting in a lower annual percentage of 0.028%. However, the cumulative percentage continued to grow, reaching 0.066%.
In 2024, there was a modest increase in X-ray scans to 345, accounting for 0.031% of the population and bringing the cumulative percentage to 0.097%.
In 2025, a significant change occurred. With the addition of Alpha2 and Panoramic digital X-ray centres at the beginning of the year, the total X-ray scan count dramatically increased to 1,668. This represents a substantial 0.148% of the population for that year, marking a considerable rise compared to previous years. Consequently, the cumulative percentage of the population with digital X-ray records reached 0.245%.

Figure 2. Scan and population growth count graph



Using percentage change analysis from Table 1, the scan count in 2022 represents the initial value (391 scans) and the scan count in 2025 represents the final value (1,668 scans). When applying these values to the percentage change equation:

$$\text{Percentage Change} = ((\text{Final Value} - \text{Initial Value}) / \text{Initial Value}) \times 100$$
$$\text{Percentage Change} = ((1{,}668 - 391) / 391) \times 100$$
$$= (1{,}277 / 391) \times 100$$
$$= 3.266 \times 100$$
$$= 326.6\%$$

The data, as shown in Figure 2, demonstrates an ascending increase in the cumulative percentage of the population with digital X-ray records, despite some annual variations in scan counts prior to 2025. The substantial increase in X-ray scans in 2025 directly correlates with the expansion of digital X-ray facilities in Kirkuk. This growing database of digital dental records holds significant potential for enhancing disaster victim identification efforts by providing a readily accessible and detailed source of ante-mortem dental information.

4. DISCUSSION

The enhancement of medical services has raised the demand for 2-dimensional and 3-dimensional imaging, leading to a shift in contemporary antemortem and postmortem data from conventional radiographs to more technologically advanced imaging modalities. This modification benefits the human identification process by enabling more realistic and reliable forensic data comparisons [16,17]. Advanced innovations play a significant role in forensic odontology, with the potential to reduce both working time and the number of investigators needed at actual disaster sites. By adopting these innovations [18], resources required to create a secure working environment for investigators can be reallocated to restoration efforts in the disaster zone. The installation of the first extraoral digital dental radiograph (Alpha1) in 2022 led to annual scan counts of 391, 305, and 345 from 2022 to 2024, respectively, alongside steady population growth (1.05M to 1.10M). No correlation existed between the population increase (4.8% over two years) and scan volume, which declined by 11.8% from 2022 to 2024, as only one (Alpha) unit was operating. In 2025, with the addition of Alpha2 and Panoramic units (January 2025), scan records until May 1, 2025, showed 1,668 scans—a 383% increase from 2024.

This growth dramatically outpaces the population rise (2.5% year-over-year), confirming that infrastructure expansion, not demographic change, drives this acceleration. The cumulative total reached 2,709, and the cumulative percentage was 0.245 compared to the city center population of 1,128,000; this number of X-rays serves as a reference that can be used as antemortem data for disaster victim identification, particularly in Iraq. The percentage change analysis is 326.6%, indicating a significant increase from the initial value to the final value. High-tech imaging methods are especially useful in complicated instances involving skeletal remains and decomposed or charred bodies, where soft tissues and fingerprints are often damaged [19,20]. Iraq, as a developing country, lacks systematically documented dental X-ray basic data for its citizens that could serve as a source of antemortem images for forensic odontology.

In contrast, people in medically developed countries may have their images stored in hospitals and medical centers or can bring their own images as recorded media. Radiographs are crucial for forensic examinations because they offer independent verification of anatomical conditions and dental procedures performed up to a given point in time. They are advantageous due to their speed, ease of use, and non-destructive nature, and they are less expensive than DNA technology [21,22]. Computed radiography, the first successful digital radiography instrument, was created in 1983, and more recently, imaging technologies in medically developed nations have completely shifted to digital [23]. Through a direct interview with a radiology center owner, it was learned that there is an awareness of the importance of information in identifying disaster victims, but not according to scientific standards. Major obstacles include a lack of time, financial burden for storage capacity management, and advanced education in data management. Since scan images and photographs must be used for court proceedings, it is crucial that they are maintained properly for therapeutic purposes [24].

The careful preservation of ante-mortem documents by dental professionals and organizations is essential to the success of forensic dentistry. Essential details such as the person's name, age, sex, number of teeth, dental restorations, dentures, and morphological variations in teeth and mucosa—backed up by photos and radiographs—should be included in these records [25]. Radiography and imaging procedures are becoming essential parts of contemporary medical treatment and play a major role in making decisions in forensic medicine that are beyond a reasonable doubt. Health care providers are required to document the radiographic images and information obtained during treatments. As a specialized field, forensic radiology has the potential to be a useful tool for solving crimes [26].

Limitations and Suggestions

This study is limited by its sample size, which comprises only three clinics. While this restricts the broad generalizability of the findings to all private clinics in Kirkuk, it does offer a focused snapshot of recent adopters of digital radiography. The research assesses perceived preparedness and capabilities rather than actual performance during a real disaster victim

identification event. Additionally, because the Centers Alpha2 and Panoramic only began operation in January 2025, the data reflects their initial implementation phase, and longer-term trends remain to be seen.

It is important for operating staff to receive specialized training on digital systems and to be aware of disaster victim identification protocols and standards, such as the Interpol disaster victim identification guide. Familiarity with the use of dental records for identification is essential. Since images may be deleted following a set retention period—except for clinically significant or unusual cases—developing a centralized data record or using external hard drives for data preservation is recommended. Licensing authorities should ensure that radiology centers maintain patient and radiological information in a scientifically regulated manner. Annual collection of radiology and patient information in an encrypted central storage center is advised to prevent neglect and loss. Adopting standardized dental identification charts in accordance with Interpol recommendations, which incorporate both antemortem and postmortem records, is recommended for the identification process.

5. CONCLUSION

The study provides a picture of the number of X-rays stored within radiology centers, especially the total cumulative number and positive percentage change over several years, as well as the future vision for the use of X-rays in disaster victim identification. As DNA profiling may be affected by fire or environmental factors and is time-consuming and expensive, the availability of digital X-ray data, which can be easily and rapidly transmitted with no loss of accuracy or detail, can greatly speed up the response in disaster victim identification operations as a source of antemortem data. Strategic investment in medical imaging infrastructure can directly and rapidly increase service provision, which is vital for surge capacity during mass casualty events requiring disaster victim identification.

Conflict of Interest

The authors declare no conflicts of interest in this study.

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Authors Contribution

Conceptualization: MJR, AGZ; Methodology; Analysis: AGZ; Draft Writing: MJR, AGZ; Supervision and Editing: MJR; Administration

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Reference

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