

American Dental Association
Technical Report No. 1088

Human Identification by Comparative Dental Analysis

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Standards Committee on Dental Informatics

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AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1088 FOR HUMAN IDENTIFICATION BY COMPARATIVE DENTAL ANALYSIS

The ADA Standards Committee on Dental Informatics (SCDI) has approved American Dental Association Technical Report No. 1088 for **Human Identification by Comparative Dental Analysis**. Working Groups of the ADA SCDI formulate this and other specifications and technical reports for the application of information technology and other electronic technologies to dentistry's clinical and administrative operations. The ADA SCDI has representation from appropriate interests in the United States in the standardization of information technology and other electronic technologies used in dental practice. The ADA SCDI confirmed approval of ADA Technical Report No. 1088 on January 26, 2017.

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AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1088 FOR HUMAN IDENTIFICATION BY COMPARATIVE DENTAL ANALYSIS

FOREWORD

(This Foreword does not form a part of ADA Technical Report No. 1088 for Human Identification by Comparative Dental Analysis).

In 1992, there was interest in the standardization of clinical information systems related to electronic technology in the dental environment. After evaluating current informatics activities, a Task Group of the ANSI Accredited Standards Committee MD156 (ASC MD156) was created by the ADA to initiate the development of technical reports, guidelines, and standards on electronic technologies used in dental practice. In 1999, the ADA established the ADA Standards Committee on Dental Informatics (SCDI). The ADA SCDI is currently the group that reviews and approves proposed American National Standards (ANSI approved) and technical reports developed by the standards committee's working groups. The ADA became an ANSI accredited standards organization in 2000.

The scope of the ADA SCDI is:

"The ADA SCDI shall develop informatics standards, technical reports and guidelines and interact with other entities involved in the development of health informatics standards aimed at implementation across the dental profession."

AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1088 FOR HUMAN IDENTIFICATION BY COMPARATIVE DENTAL ANALYSIS

INTRODUCTION

The establishment of a positive identification of unknown human remains or an unidentified living individual by comparative dental analysis requires both the submission of supporting documentation from the dental provider (s) who treated the patient as well as careful documentation of the unidentified remains or an unidentified living individual. Human Identification by dental analysis is the comparison of oral maxillofacial structures. The procedures to reconcile this information (e.g., radiographs, charts, and progress notes) have been outlined by numerous forensic organizations including the American Board of Forensic Odontology (ABFO), American Society of Forensic Odontology (ASFO), British Association of Forensic Odontology (BAFO), Disaster Mortuary Operational Response Team (DMORT), Interpol's DVI Steering Committee Forensic Odontology Subcommittee as well as many others.

The goal of this technical report is to provide the best available current information to forensic odontologists, forensic pathologists, medical examiners and coroners, law enforcement personnel, dental schools, emergency planners and others on the best practices recommended by the forensic odontology community. It includes guidelines on how to obtain comparative forensic dental data as well as the recommended methodologies to reconcile that data in order to establish an identification by comparative dental analysis.

1 BACKGROUND

In the United States, the identification of unidentified living individuals is the responsibility of local, state or federal law enforcement agencies. The Medical Examiner or Coroner (ME/C) has the statutory responsibility and judicial authority to identify the deceased. Although it is ultimately these agencies that certify the identification it is the responsibility of the forensic odontologist to provide their opinion on the identity as it relates to forensic odontology. Those opinions are based on a standardized set of guidelines established by the forensic odontology community and are based on scientific best practices.

The positive identification of an individual is of critical importance for multiple reasons that include:

For unidentified living individuals:

- A positive identification is vital to reunite an unidentified living individual with their family members.

For the human remains:

A positive identification is vital to help family members progress through the grieving process, providing some sense of relief in knowing that their loved one has been found.

- A positive identification and subsequent death certificate is necessary in order to settle business and personal affairs.
Disbursement of life insurance proceeds, estate transfer, settlement of probate, and execution of wills, remarriage of spouse and child custody issues can be delayed for years by legal proceedings if a positive identification cannot be rendered.
Criminal investigation and potential prosecution in a homicide case may not proceed without a positive identification of the victim.

Since the consequences of a misidentification can have emotional and legal ramifications the use of other identification modalities include ridgeology, DNA, or other scientific methods of identification (see Section 6 Scientific Methods Of Identification below) should be considered especially if there is any ambiguity in the comparative dental analysis.

2 RATIONALE

Forensic odontologists are responsible for identifying unknown human individuals by comparative dental analysis. This process requires comprehensive collection and processing of dental data in order to prove or disprove a human identification. The goal of this technical report is to establish current best practices for this process based on the most up to date technology. The intent of this technical report is not to supersede local, state, or federal jurisdictional guidelines but serve as a tool for the development of those guidelines.

3 SCOPE

The scope of this technical report is to develop a recommend set of guidelines for the process of identifying humans by comparative dental analysis. A goal of this technical report is to create awareness and education for the dental practitioner on the forensic odontology identification process as well as understand what information may be required should the need for them to participate occurs.

4 NORMATIVE REFERENCES

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1942 Dentistry – Vocabulary

ISO 3950, Dentistry — Designation system for teeth and areas of the oral cavity

ANSI/ADA 1058-2010, Forensic Dental Data Set

(ANSI/ADA standards and ISO standards for dentistry are available from the American Dental Association, Standards Department, 211 E. Chicago Ave., Chicago, IL 60611 or www.adacatalog.org).

ANSI-NIST ITL 1-2011 Update 2015 NIST Special Publication 500-290 Rev2 (2015)

(NIST publications are available from www.nist.gov)

ASTM E1732 – 12 Standard Terminology Relating to Forensic Science

ASTM E1459 – 13 Standard Guide for Physical Evidence Labeling and Related Documentation

ASTM E1188 – 11 Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator

ASTM E678 - 07(2013) Standard Practice for Evaluation of Scientific or Technical Data

ASTM E620 – 11 Standard Practice for Reporting Opinions of Scientific or Technical Experts

(ASTM Standards are available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428 or www.astm.org).

HIPPA 45 CFR (Code of Federal Regulations)

(The HIPAA regulation is available from <http://www.hhs.gov/hipaa/>).

5 CONVENTIONS USED IN THIS DOCUMENT

The term **dental provider** will refer to any individual who can legally provide the services requested. In addition, whenever forensic odontological services are required the dental provider must have additional forensic odontological training and skills to provide a legally recognized competent medical opinion concerning the comparative dental analysis. The credentialing of individuals is beyond the scope of this document.

Dental identification involves comparing 'prior dental data' to the available dental data of the remains or unknown individual in his/her current state. The term **prior data** refers to data collected when that individual was in a previous known and documented state/condition and does not mean a specific point in time. The term **current data** refers to the available data for the individual or remains in his/her current state. For disaster victim identification and unknown deceased identification prior data is referred to as antemortem (pre death) data while the current data is referred to as postmortem (post death) data. For a person unable (or unwilling) to identify themselves the data is simply referred to as prior dental data and current dental data both of which are technically antemortem data.

Since the focus of this Technical Report is on identification of the deceased, for the sake of simplicity, the term **antemortem dental data** will be utilized to refer to historical dental data collected by an independent third party, typically a dental professional, regardless of whether that individual is currently alive or deceased. Typically, this individual has been reported missing to a law enforcement agency and the whereabouts of the individual is unknown. The use of this term in this document could also refer to historical dental data of an unidentified living individual.

The term **postmortem dental data** will refer to the current dental data collected by a representative of the ME/C, typically a dental professional, of a disaster victim or an unknown deceased individual. While, by definition, there would be no "postmortem dental data" for an unidentified living individual the "current dental data" serves the same function as "postmortem dental data."

The terms **remains** and **decedent** will refer to the unknown individual whose identity needs to be established by comparative dental analysis. Therefore, the use of these terms in this document could also refer to an unidentified living individual.

It is beyond the scope of this document to include specific procedural methods or techniques.

5.1 Visual

A non-scientific method is often used when there is little doubt who the individual is, when the remains are not decomposed, and/or the death was witnessed. However, changes in appearance from illness, the circumstances of death, (fire, trauma, disintegration, etc.) and postmortem taphonomic effects, (decomposition, mummification, saponification, skeletonization, animal predation/scavenging, insect activity, etc.), may render it unreliable.

Tattoos, scars, piercings, subdermal body modification, and soft tissue abnormalities are useful for visual identification, especially if the tissue is intact. It is important to note, that, although personal effects are often found with the remains or at the scene (identification cards, jewelry, cell phones, etc.), they should never be used as the sole means of establishing an identification due to the possibility that these items were exchanged between individuals. However, they may offer important clues for a presumptive identification and assist in obtaining antemortem data on the individual to allow for a scientific identification.

In the future, the potential to establish a large facial image database based on facial recognition data may be possible; however, currently, these databases are extremely limited in size. However, even these limited databases could be utilized to establish a presumptive identification and could assist in obtaining antemortem information in order to establish a more scientific basis of identification.

5.2 Ridgeology (Fingerprints, palm and footprints)

Ridgeology is an expedient biometric method of human identification, especially if the soft tissue of the fingers are intact, an adequate impression or image of the friction ridges can be obtained, and antemortem fingerprint records are available. Burned, decomposed, skeletonized and fragmented remains may be more difficult, if not impossible, to image, however, newer techniques have reduced this problem. This method has the advantage of large known national and international databases and does not require a presumptive identification in order to obtain antemortem information.

5.3 Anthropology/Radiology

Anthropology, combined with radiology relies on the unique characteristics of the skeleton to compare with antemortem medical imaging and records. Radiographs of skeletal anatomy, bony anomalies, healed fractures, pathological lesions, medical/surgical hardware and implants, or unusual qualities of the skeleton can be used to confirm identification. However, many individuals do not have antemortem skeletal imaging, or the images may not be available. However, the biometric uniqueness of a pathological condition or image of an implanted medical device (unless a serial number of an implanted device exists,) may be questioned.

5.4 DNA

Like other biometric methods of identification, DNA comparison relies on access to antemortem data to make a definitive identification. However, unlike other modalities, familial relationship can be established even when antemortem data is not available. In addition, like ridgeology (fingerprints) large national databases are currently being established that can reduce the need for a presumptive identification especially if the decedent has had contact with the justice system. Direct primary and secondary reference samples from the decedent during life are the best sources for identification and indirect DNA reference samples from biological relatives can prove useful in establishing a relationship. DNA testing requires more time, effort, specialized personnel/equipment, and higher cost than other identification methods. The majority of forensic DNA tests are performed on nuclear DNA using polymerase chain reaction (PCR) amplification of the sample with short tandem repeat (STR) typing. Simultaneous analysis of mitochondrial DNA (mtDNA) may be necessary in order to improve the identification process. Forensic DNA analyses for human identification has seen a tremendous implementation since the President's DNA Initiative Program began in 2003. This program has facilitated funding, training, and assistance to ensure forensic DNA reaches its full potential to identify missing persons. From this program, the National Institute of Justice now provides funding to have DNA analysis done on unidentified remains and family reference samples, at no cost, by the Center for Human Identification at the University of North Texas, or by the FBI. Once the analysis is complete, the profiles (if they qualify) are entered into the FBI's CODIS system (Combined DNA Index System) and uploaded into the National DNA Index System.

5.5 Dental

Comparative dental analysis of human remains is one of the most common, and often, the most expedient and efficacious biometric method for identifying burned, decomposed, skeletonized and fragmented remains. This method involves the comparison of antemortem dental information to postmortem dental information, typically

based on radiographs but also with written records, three-dimensional models, as well as intraoral and extraoral photographs of the decedent.

6 DENTAL IDENTIFICATION

Dental identification of a deceased person is a primary function of forensic odontology. The comparison of a missing person's antemortem dental records/evidence (i.e., written records, study casts, photographs/digital images and radiographs) with the postmortem dental evidence from unknown human remains has long been recognized as one of the most reliable means of positive scientific identification.

7 TYPES OF DENTAL INFORMATION

7.1 Oral and Dental Record

In the case of a missing person, a dental record includes all the historical data including the complete clinical, radiographic and photographic examination of the oral cavity (see Section 9 Collection And Preservation Of Antemortem Dental Evidence below). In the case of a decedent or unidentified living individual, the current examination should include the same information (see Section 10 Collection And Preservation Of Postmortem Dental Evidence below).

The clinical examination may be recorded on a paper chart or digitally using an electronic dental record. Teeth are typically numbered using the locally recognized numbering system. In the United States, this is the Universal Numbering System (see Section 10.3.1 Numbering Systems, Narrative Descriptors and Nomenclature below). For most other countries, it is typically ISO 3950 2009-05-15 Dentistry — Designation system for teeth and areas of the oral cavity.

Basic data should be recorded in the comparative dental record and include the name or case number, the date and time of the examination, the jurisdiction or authority for the examination, the location of the examination and all relevant demographic data. Additionally, if the data being recorded is of a decedent the remains description including the approximate age, sex, biologic affinity and postmortem condition should be documented.

The record should reflect any missing dental structures or jaw fragments as well as those present and available for evaluation. An odontogram (graphic chart of the condition of the teeth) should illustrate as graphically as possible the following:

- Clear annotation of tooth numbering and surfaces;
- Configuration of all dental restorations (including prostheses), caries, fractures, anomalies, abrasions, implants, erosions or other features for all teeth;
- Materials used in dental restorations and prosthetic devices, when known;
- Periodontal conditions, calculus, stain;
- Occlusal relationships, malposed teeth, anomalous, congenitally missing and supernumerary teeth.

Any additional oral features, e.g., amalgam tattoo, lip, tongue stud, or similar decorative foreign body, bifid uvula, etc.

Clinical extraoral findings of the head and neck may also be of use in supporting or excluding the identification. Although, this is not a scientific identification by comparative dental analysis, this contextual data may be useful to the ME/Coroner.

7.1.1 Foreign Dental Records

Care should be taken whenever foreign dental records are received especially concerning tooth numbering (see Section 10.3.1 Numbering Systems, Narrative Descriptors and Nomenclature below). Whenever possible the dental provider who is both fluent in the language of the dental chart and has familiarity with the dental protocols from the country of origin of the chart should be utilized to verify that the data has been correctly transferred.

7.1.2 The Electronic Dental Record (EDR)

The electronic dental record is defined by the American Dental Association as a complete longitudinal history of an individual's dental care across all settings and encounters as well as the data types and relationships that would enable it to be created, stored, and managed electronically. Its structure, content and implementation requirements are covered in ANSI/ADA Standard No. 1067-2013 Electronic Dental Record System Standard Functional Requirements. The EDR is a primary source of antemortem dental information.

7.1.2.1 Antemortem EDR

Whenever possible electronic dental records should be used. Obtaining an antemortem EDR reduces the possibility of misinterpreting a chart due to illegibility. As with a paper chart, the EDR should include the condition of the teeth and oral condition as well as all treatment rendered. Ideally, this information should be accurately transferred to the comparative dental record, charted on an odontogram, and annotated as necessary with the dental status of each tooth including dental restorations, prostheses present, condition of the periodontium, pathologies present, bone and soft tissue anomalies, other anomalies, etc. Because of the diversity in EHR's, care should be taken to interpret the Odontogram properly. Currently, the only standardized format for the transfer of dental forensic data is ANSI-NIST ITL Type 12 Data Set (see Section 15.1.3 ANSI/NIST/ITL Standard below) which has yet to be widely adopted. Because of this limitation, EDR data may have to be transmitted in a paper format or as a PDF document. In addition, Proposed ANSI/ADA Technical Report No. 1085 Implementation Guidelines for the Secure Transmission of Protected Health Information in Dentistry should be consulted to insure that proper security protocols are followed concerning the transfer of this data.

7.1.2.2 Postmortem EDR – The Comparative Dental Record

As with all EDRs the recording of postmortem information electronically greatly reduces the possibility of errors. Some dental forensic packages have built in data verification algorithms that will further reduce the possibility of data entry errors. The teeth and oral condition should be accurately charted on an odontogram and annotated as necessary with the dental status of each tooth including dental restorations, prostheses present, condition of the periodontium, pathologies present, bone and soft tissue anomalies, other anomalies, etc. As with the antemortem EDR, care should be taken to properly understand all the symbols used in the Odontogram. Currently, the only standardized format for the transfer of dental forensic data is ANSI-NIST ITL Type 12 Data Set (see Section 15.1.3.1 Record Type-12: Forensic Dental And Oral Record below) which has yet to be widely adopted. Because of this limitation, EDR data may have to be transmitted in a paper format or as a PDF document. In addition, Proposed ANSI/ADA Technical Report No. 1085 Implementation Guidelines for the Secure Transmission of Protected Health Information in Dentistry should be consulted to insure that proper security protocols are followed concerning the transfer of this data.

7.2 Dental Radiographs

Every postmortem dental examination must include dental radiographs. An accurate dental examination without

dental radiographs is not possible, since there are many conditions that are only detectable with them; e.g. endodontically treated teeth, retained roots, impacted teeth, etc. Dental radiographs are the documentation that will be needed to substantiate conclusions. People can make recording errors in a chart, but radiographs are objective recordings of the dental characteristics/evidence. A thorough postmortem dental radiographic examination should include a complete series of periapical images of the available dental structures. Bitewing radiographs / projections / angulations should be included because they are the most common type found in antemortem dental records. In cases where a complete set of radiographs may not be obtainable, as complete an examination as possible should be performed. When taking postmortem radiographs the operator should be cognizant that the purpose of these images is for comparison to images taken when the decedent was alive. It is important that postmortem radiographs be properly angulated, exposed, processed and digitally enhanced as necessary. Other dental related postmortem radiographic images may include panoramic and occlusal imaging and CT imaging of the head.

7.3 Types of Dental Radiographs

7.3.1 Intraoral Radiographs

Conventional (film) or digital dental bitewing and periapical radiographs of the anterior and posterior teeth should be made in a consistent manner on all decedents and unidentified living individuals. A full mouth series of dental radiographs consisting of eighteen (18) radiographs should be made on adults with an intact dentition, which would include four (4) bitewing dental radiographs and fourteen (14) periapical dental radiographs. In lieu of conventional bitewings, a bitewing “projection” could be taken with the teeth out of occlusion using separate views of the upper and lower teeth with a horizontal bitewing angulation.

Although fewer radiographs may be taken when there are fewer teeth present or the dental evidence is fragmented, edentulous areas still need to be visualized. Edentulous areas or arches must be included in a radiographic exam as well as the empty alveolar sockets of teeth that have been lost postmortem. Occlusal exposures may be used for objects larger than a periapical film and may be helpful in radiographic documentation of the deciduous dentition.

Since the quality of the antemortem and postmortem radiographs will affect the ability to make a positive dental identification, it is imperative that, whenever possible, high quality images are obtained. The original antemortem radiographic images should be requested from the missing person’s dental provider; however, the missing person’s dental provider must still keep a duplicate set within the patient’s record. For digital film, high-resolution single image radiographs should be sent along with a composite structured display (“mounted film”) image for location verification. Data transfer should follow ADA recommendations that include utilizing DICOM protocols (see Section 8.3.7 Electronic Transference of Data below). In cases where DICOM protocols cannot be utilized, the images should be properly annotated with the appropriate demographic data (name, date of birth, date of radiograph, etc.). A dental radiographic dot must be clearly visible on all images and special care should be exercised with some Phosphor Storage Plates (PSP) imaging systems where image reversal is possible (see Section 8.3.8 Data Discrepancies below).

7.3.2 Panoramic Radiographs

This type of image provides a large single radiograph that shows both jaws, the sinus cavities, nasal passages, lower portions of the orbits, and the angles of the mandible. The film is made with the head stabilized in a cradle while the x-ray source and the film cassette travel around the head. These images are not routinely taken in most dental offices; however, they are common enough that their use in forensics has to be considered. They should be used for comparison to antemortem dental images cautiously if the antemortem images are of a different type.

Sometimes, the individual teeth and supporting structures may overlap or be distorted, making comparison to other film difficult. In addition, the logistics of positioning a decedent's head, jaw or jaw fragments, onto the machine may prevent the production of a quality image.

7.3.3 Cone Beam Tomography

Cone beam computed tomography (CBCT) is a medical imaging technique consisting of X-ray computed tomography where the X-rays are divergent forming a cone, not thin or fan-shaped such as that used in typical medical computerized tomography (CT) units.

During dental imaging, the CBCT scanner rotates around the patient's head, obtaining 300 or more distinct images through 360 degrees of rotation. As a 3D rendition, CBCT offers an undistorted view of the dentition that can accurately visualize both erupted and non-erupted teeth, tooth root orientation and anomalous structures that conventional 2D radiography cannot.

CBCT has become increasingly important in treatment planning and diagnosis in implant dentistry, orthodontics, endodontics, oral surgery and interventional radiology (IR). The resolution of the images can range from 0.4 mm to as small as 0.125 mm in some units and the implications for forensic dental identification are enormous.

In addition to creating 3D images of the bone and facial soft tissue, any intraoral or extraoral film image view can then be reconstructed from one scan with the ability of the operator to select the desired slice location and orientation. Thus, a panoramic image can be recreated with an adjustable thickness or zone of sharpness and there are no superimposed anatomical structures. In addition, algorithms correct for the geometric distortions that are present in all two-dimensional images. There is no magnification and the images are 1:1 representations.

Two drawbacks of CBCT technology over that of medical-grade CT scans are the increased susceptibility to movement artifacts (especially in first generation machines) and the lack of appropriate bone density determination as measured in Hounsfield Units. The latter issue is of little significance with regard to dental identification.

The continued and increasing utilization of CBCT imaging technology in the field of dentistry is creating a new set of valuable forensic data. CBCT imaging technology allows for the reconstruction of standard dental radiographs from postmortem remains and allows for the possibility of three-dimensional superimposition of antemortem and postmortem virtual data for matching and identification. CBCT records also allow for virtual archiving of specimens, tele-forensic techniques, and Automated Dental Identification Systems. The possibilities of a CBCT scan use on decedents in a mass disaster should be considered if funding considerations can be addressed. A single scan of the victim could later be compared to any possible variety of submitted antemortem dental images (i.e. bitewings, periapical, panoramic, occlusal, PA skull, Waters view, etc.).

7.3.4 Medical Radiographs

These radiographs are made for orthodontic purposes or for diagnosis of head injuries, sinus problems, etc. They usually show the entire skull from a particular view or exposure. While anatomic features such as the sinuses, especially the frontal sinus in an anterior/posterior view or a Waters' view, can be depicted, the visualization of the teeth may be difficult due to overlapping of teeth, superimposition of the right and left sides of the arches and other types of distortion. All of these factors can make comparison of specific dental features difficult. However, medical computed tomography (CT) imaging of the head could be helpful when the scan includes the teeth and the jaws. These types of advanced images can allow visualization of the teeth and oral structures in the axial, coronal, and sagittal planes, 3-D reconstruction, and can mimic dental bitewing, periapical, and panoramic radiographs.

7.3.5 Photographs

Dental photographs may also be helpful in comparative dental identification and in documenting dental evidence, especially when there are unique dental features that would be difficult to describe. Photography can provide a double check for possible recording errors. Photographs, particularly those of the anterior teeth, may be useful for comparisons to antemortem photographs that show unusual features of these teeth. Images made could include anterior, right and left lateral, occlusal, teeth in occlusion, mandibular arch and maxillary arch views along with images of removable dental prostheses.

7.3.6 Three Dimensional Models

Three-dimensional models (study casts, working casts, 3D digital models), are often a useful source of antemortem information. Direct comparison of antemortem and postmortem dental anatomy as well as occlusal relationships may also serve as an extremely useful tool for comparative dental identification.

Three-dimensional models may also be used to preserve evidence in identification cases. It should be understood that due to the postmortem fragility of the teeth and the decomposition of the soft tissue, making impressions could alter the existing evidence. However, in certain cases, this procedure could be useful and the examining forensic odontologist should consider if making an impression is appropriate.

Preservation of dental cast evidence should be treated as any physical evidence. In addition, casts can now be digitized and stored in electronic form. The casts can also be recreated utilizing a 3-D printer.

7.3.7 Electronic Transference of Data

Ideally, EDR software would comply with American National Standard/American Dental Association Standard No. 1067-Standard Functional Requirements for an Electronic Dental Record System Section 4.2.1, Identify Participating Individuals Requirement 2.32. Therefore, the data should be sent electronically. The sections state that the "electronic dental system SHALL have the ability to reference the forensic dental data set, e.g., ANSI-NIST ITL Type 12 Dental Data Set (ANSI/ADA Specification 1058)". Its future use should be encouraged in order to allow for the unambiguous transfer of dental forensic data.

Ideally the transfer of electronic images should be done in a DICOM format and include structured display ("mounted film") information. If this is not possible, RAW, TIFF or high resolution and low-loss jpg may be used. Proprietary formats should be discouraged unless it can be verified that the recipient is able to process the format. Annotation of the image is highly recommended to prevent the possibility of errors in identifying the image. If this data is sent electronically, proper security and encryption protocols should be followed as per the American Dental Association Proposed Technical Report No. 1085 Implementation Guidelines for the Secure Transmission of Protected Health Information in Dentistry.

7.3.8 Data Discrepancies

Additional protocols should be in place to verify any discrepancies within the dental chart and between the dental radiographs and the dental chart in order to verify the causes. The possibility of charting errors, an incomplete chart, and treatment rendered in multiple locations, as well as possible fraud should always be considered. Additional errors include mislabeling or mis-mounting of radiographs. Film reversal, a known issue with some Phosphor Storage Plates (PSP) imaging systems, should also be investigated as a possible source of errors.

Ideally, a review board should be set up to make a final interpretation of ambiguous data and memorialize these coding rules so that a consistent coding protocol is in place with documentation for future reference.

8 COLLECTION AND PRESERVATION OF ANTEMORTEM DENTAL EVIDENCE

8.1 BACKGROUND

Most methods of scientific identification, (dental, friction ridge [fingerprints], anthropologic/medical/radiographic, and DNA), rely on the comparison of the postmortem evidence to antemortem biometric data of the putative decedent to make or exclude an identification. The exception is mtDNA, which can also utilize a family member's biometric data if said family member is related along the maternal line.

Antemortem dental records should be obtained from the most recent dental provider of the decedent as well as past providers as necessary. The antemortem dental records requested by the investigator should include the entire dental record: dental radiographs, written notes, odontograms, periodontal charts, treatment notes, photographs, study casts and dental laboratory prescriptions or notes. Medical imaging of the head and neck can be quite useful in comparison with the postmortem dental evidence and should be obtained if available. These might include CT scans, conventional head radiographs (lateral, lateral oblique, AP), Water's view (occipito-mental), odontoid, and others. Documented referrals to and from other providers can provide an additional source of antemortem data, including images and procedural information.

8.2 Types of Antemortem Information

A forensic odontologist should be retained to perform the examination of the antemortem dental chart and record the necessary information to assure that all recorded information is accurate and preserved in a report for potential comparisons. A complete visual inventory and written catalogue of all of the available antemortem dental evidence is critical to any forensic dental examination.

The forensic dental chart of the antemortem condition (odontogram) should allow for adequate notations via either words and/or diagrams for all existing conditions. Charting designations for teeth should use a locally recognized numbering system. In the United States, this is the Universal Numbering System (see Section 10.3.1 Numbering Systems, Narrative Descriptors and Nomenclature below)

8.3 Sources of Antemortem Data

Antemortem data may include dental radiographs, written records, three dimensional models, (study casts, working casts, 3D digital models) prostheses and appliances. Collection of antemortem records is ordinarily the responsibility of the investigative agency that has access to missing persons reports at the local, state or national level. However, the forensic odontologist may recognize additional characteristics (e.g., prior orthodontic treatment) which could be helpful in establishing a putative identification. This section lists a variety of resource agencies and/or individuals that might provide assistance in locating records.

8.3.1 Dental Offices

Whenever a presumptive identification or a manifest is available, every effort should be made to identify any dental professional that may have treated that individual. Direct contact with relatives, friends, employment sources, insurance sources, banking and credit card records, government agencies, or any social media sources should be researched as possible resources for dental record information. Access to any personal electronic devices as well as cloud sources also should be investigated

8.3.2 Denture Labeling

Denture labeling or marking may be crucial during a medical-legal investigation to help identify an edentulous or partially edentulous person that wears a dental prosthetic device. This is not only important for the identification of deceased and injured people in daily casework and mass casualty incidents, but to also assist nursing home care providers, hospitals, institutions and those that provide care for people who wear dentures. The importance of denture labeling has long been acknowledged by forensic organizations, the American Dental Association, and dental laboratories with the recommendation that removable dental prostheses be labeled with at least the patient's (wearer's) name and be **legible, permanent, clinically safe and cosmetically acceptable**. In many of the states of the US, the labeling of dentures is mandated by legislation.

Denture labels or markers should be biologically inert when incorporated into the denture, inexpensive, easy and quick to apply, possible to retrieve after an accident, acid resistant and survive elevated temperatures. The marking must also be esthetically acceptable, visible (readable) and durable without jeopardizing the strength of the prosthesis. In addition, the marking should be permanent and resistant to everyday cleansing and disinfecting agents. The most common areas for marking are the posterior regions of the lingual flange of mandibular dentures, the palate and posterior buccal flange of maxillary dentures.

Two types of identification marking techniques can be performed: surface marking and inclusion methods. Surface marking is usually achieved by carving or engraving the patient's identifier on the cast before laboratory processing, or writing on the denture surface after processing. Inclusion methods place identification labels or devices within the denture's acrylic resin. One method is to create a recess in the denture base after fabrication, and place an identifying label, which is then sealed with auto-polymerizing acrylic resin. A second method is to place the label directly into the base plate during packing and processing of the prosthesis. Besides a label, other devices or techniques that may be used including embossed metal foil, metal bands, lenticular cards, laser etching, RFID chips, bar codes, and microchips.

8.3.3 Local Agencies

Hospitals, Other Health Care Facilities

Dental Schools

Health Care Providers

Employer Dental Insurance Carrier

Public Aid Insurance Administrator

8.3.4 State Agencies

A list of state agencies is maintained on the ABFO website: www.abfo.org

8.3.5 U.S. Military Records

Department of Veterans Affairs

Service Record/Dental Records

P.O. Box 150950

St. Louis, MO 63115

National Personnel Records Center
9700 Page Ave.
St. Louis, MO 63132-5100

8.3.6 Federal Agencies

FBI National Crime Information Center (NCIC)
NCIC/FBI Building
10th and Pennsylvania
N.W. Washington, D.C. 20535
(202) 324-5049

National Missing and Unidentified Persons System
NamUs
www.Namus.gov

U.S. Dept. of Justice
Washington, D.C.
Military Records Depository
900 Page Blvd.
St. Louis, MO

8.3.7 International Resources

UK Derek Clarke, London Hospital, Medical College
Canada, Robert Dorion, D.M.D., Montreal
Germany Dr. Klaus Raucher
Australia Dr. Kenneth Brown University of Adelaide, SA
Interpol

8.3.8 Insurance Carriers

Dental Relations Committee
The Health Insurance Association of America
1025 Connecticut Avenue, N.W.
Washington, D.C. 20036

Council on Dental Benefit Programs
American Dental Association
211 E. Chicago Avenue
Chicago, IL 60611

Illinois Blue Cross
233 N. Michigan
Chicago, IL 60601

Delta Dental Plan
1515 W. 22nd St.
Oak Brook, IL 60523

8.3.9 Other Sources

Family/Friends/Co-workers
Public Aid Insurance Administrator
Employer Dental Insurance Carrier
Prior Military Service
City, County, State or Federal Penal Institutions
Prior Hospitalizations (e.g. Chest Images, Skull Images, Advanced Imaging [CT, MRI, CBCT])
Oral Surgeons or Orthodontists in the Area
Veterans Administration Hospitals
Any Previous Areas of Residence
Chiropractic X-rays

8.3.10 Websites

Numerous websites are available that can provide data to assist in the identification process.

8.3.10.1 National

American Association of Missing and Exploited Children's Organizations (AMECO)

<http://www.amecoinc.org/clearinghouse.htm>

Center for Disease Control and Prevention. National Violent Death Reporting System,
<http://www.cdc.gov/ncipc/profiles/nvdrs/default.htm>

National Center for Missing Adults (NCMA)

<http://www.theyaremissd.org/ncma>

National Crime Information Center (NCIC)

<http://www.fbi.gov/hq/cjisd/ncic.htm> (not open to the public)

National Missing and Unidentified Persons System (NamUs)

<http://www.NamUs.gov> (National online repository for missing persons and unidentified dead cases)

The NamUs initiative brings together two innovative programs and their online searchable databases
<http://www.identifyus.org> and <http://www.find-the-missing.org>

The Doe Network (International Center for Unidentified and Missing Persons)

<http://www.doenetwork.org>

National Center for Missing and Exploited Children (NCMEC)

<http://www.missingkids.com> (Input from the public accepted 1-800-THE LOST)

North American Missing Persons Network (NAMPN)

<http://www.nampn.org>

National Dental Image Repository (NDIR)

Available only at Law Enforcement on Line Email images to NDIR@leo.gov

8.3.10.2 State and Local

California Missing Persons (1-800-222-FIND)

<http://www.ag.ca.gov/missing>

Clark County Coroner's Office (Las Vegas, NV)

<http://www.acesclarkcounty.net/coroner/unid.htm>

Colorado Coroners Association

<http://www.coloradocoroners.org>

Florida Unidentified Decedents Database

<http://www.fluiddb.com>

Florida Unidentified Deceased Initiative

http://www.fdle.state.fl.us/cjst/mec/identifyingunidentifieddeceased/identifying_deceased.html

Fulton County Medical Examiner's Office

<http://www.fcmeo.org/uidtrifold.htm> (Unidentified Victim's Listings)

Georgia Unidentified Remains (Cases from the Georgia Bureau of Investigation)

<http://www.ganet.org/gbi/uidlist.cgi/>

Illinois State Police – Unsolved Cases

<http://www.isp.state.il.us/crime/unsolved.cfm>

Iowa Unidentified Persons and Bodies
http://www...dps.state.ia.us/dci/unidentified_bodies/index.shtml

John and Jane Doe Case Files (Coroner's Division of the Orange County Sheriff-Coroner, Santa Ana, California)
<http://www.ocsd.org>

Los Angeles County Coroner
<http://coroner.co.la.ca.us/htm/uiptest.cfm>

Kentucky Office of the State Medical Examiner's Unidentified Remains Database
<http://www.unidentifiedremains.net>

LSU FACES Lab (Louisiana State University – Forensic Anthropology)
<http://www.lsu.edu/faceslab>

Maricopa County Sheriff Office (Maricopa County, Arizona)
<http://www.mcso.org/index.php?a=getmodule&mn=unsolved&page=getall>

Maryland Missing Persons Network
<http://www.marylandmissing.com/home.html>

New York State's Unidentified
http://www.troopers.state.ny.us/wanted_and_missing/unidentified/

New York State Police
<http://www.ci.nyc.ny.us/html/nypd/html/missing/missing-unid.html>

Pennsylvania State Police Files
<http://www.psp.state.pa.us/psp/cwp/browse.asp?a=3&bc=o&c=20795>

Riverside County Sheriff/Coroner's Office (Riverside County, California)
http://www.riversidesheriff.org/coroner.org/unidentified_bodies.htm

South Carolina Unidentified Persons (South Carolina Coroner Association)
http://www.sc-coroners.org/unidentified_bodies.htm

Texas Unidentified Persons (Texas Missing Persons Clearinghouse)
<http://www.txdps.state.tx.us/mpch/>

The Chattanooga, Hamilton County Medical Examiner
<http://www.hamiltontn.gov/medicalexaminer/intro.htm>

Unidentified Bodies (Office of the Sheriff, Camden County, New Jersey)
<http://www.co.camden.nj.us/sheriff/unidentified%20bodies.htm>

The New Jersey State Police,
www.njsp.org and <https://www.facebook.com/NewJerseyStatePolice>

Unidentified Human Remains (Michigan State Police Crime Laboratory)
<http://members.aol.com/stevenkl/remains.htm>

Unidentified Persons (Larimer County Medical Examiner Office, Colorado)
<http://www.co.larimer.co.us/coroner/coronerudp.htm>

Unidentified Remains (Kentucky State Medical Examiner Office)
<http://www.unidentifiedremains.net/>

8.3.10.3 International

Ontario Provincial Police (Ontario, Canada)
<http://www.opp.ca/investigative/unidentifiedremains/index.htm>

Saskatchewan Missing and Unidentified Persons (Saskatchewan Association of Chiefs of Police, Canada)
<http://www.sacp.ca/missing/index.php>

8.4 HIPAA Exemption For The Release of Dental Records:

In order to address the privacy concerns of dental offices, clinics or hospitals and to expedite a forensic investigation, the U.S. government enacted 45 CFR (Code of Federal Regulations) 164.512. This Regulation codifies the HIPAA exemption to the Privacy Rule for the release of dental records and specifically allows offices to comply with authorized agency requests. It is recommended that the exact text of the exemption be readily provided to offices in order to expedite the transfer of these records. The text reads as follows:

Section (g) of 45 CFR states: A covered entity may disclose protected health information to a coroner or medical examiner for the purpose of identifying a deceased person, determining a cause of death, or other duties authorized by the law. A covered entity that also performs the duties of the coroner or medical examiner may use protected health information for the purpose described in this paragraph.

8.5 Preservation of Antemortem Dental Evidence

The antemortem dental record needs to be preserved once it has been used to make or exclude an identification. Even if an exclusion, (i.e. a dental opinion that eliminates the possibility that an antemortem record matches a postmortem record) was the result in the initial missing person case, the antemortem record should be saved to make comparisons to unknown decedents in the future. If it is an exclusion, and policy allows, it should be inputted into a missing person database (NamUs, NCIC etc.) to be compared with unknown decedents in the future. All written, radiographic, photographic records and even the name and manufacturer of dental materials utilized in restorations (see Section 10.1.1.4.1.1.1.1.1 Characterization of dental materials by physical and chemical properties. below) should be copied or scanned and digitized using appropriate techniques, and saved in the decedent's written or digital file if an identification has been made. The original records, after having been suitably copied or digitized can be returned to the provider if requested, or stored following evidence retention policies of the local ME/C or law enforcement agencies.

9 COLLECTION AND PRESERVATION OF POSTMORTEM DENTAL EVIDENCE

9.1 Examination Procedures

The visual examination and subsequent dental charting can be a relatively easy procedure or a very tedious, difficult task, depending on the accessibility of the teeth and the condition of the remains. Where all of the teeth remain in the bony arches, forcing the jaws open, in some cases breaking the rigor mortis and cleaning the teeth is

all that is necessary. In cases of severe burning, it may sometimes be necessary to remove the upper and lower jaws so that cleaning and complete examination may be performed.

The postmortem dental examination is conducted by the authority and under the direction of the coroner/medical examiner or his designee, typically a forensic pathologist. Thus, the protocol for the collection of postmortem dental evidence, particularly decisions to incise the facial tissues for access or to resect the jaws, is subject to approval by the regional coroner/medical examiner.

The actual procedures to be followed in a dental identification case depend in large part on the condition of the remains (as well as other circumstances of the case).

9.1.1 Photography

Photographic documentation of dental evidence can provide objective data which is often more graphic than the written chart. Photographs (with an accompanying scale) should be taken before and after appropriate cleansing. The ABFO No.2 scale is recommended. The photographs should be in focus and clearly labeled with the case number/name and date. All relevant photographic information should be documented.

9.1.1.1 Recommended Equipment and Technique

Refer to ADA/ANSI Technical Report No 1029 - A Guide to Digital Dental Photography and Imaging for a detailed explanation of digital photography.

9.1.1.2 Photographic Views

Refer to ABO-01 the American Board of Orthodontics (ABO) Case Submission Display for a detailed explanation of appropriate photographic views.

Ideally, postmortem views should include:

- Full face, lips retracted;
- Close-up view of anterior teeth;
- Lateral views of teeth in slightly open position, and in occlusion;
- Occlusal views, upper and lower teeth;
- Special views, as required.

9.1.1.3 Access the Oral Cavity

Complete, unrestricted access to the oral cavity is necessary in order to conduct a thorough clinical, radiographic, and photographic dental examination of the decedent.

9.1.1.3.1 Viewable Remains

Remains that are not decomposed, incinerated, disfigured, or fragmented and may be viewed by family members or loved ones. Whenever possible, the images should be restricted to those areas necessary to allow for identification of the decedent.

9.1.1.3.2 Non-Viewable Remains

Remains may be decomposed, incinerated, disfigured, or fragmented to the extent that they cannot (and should not) be viewed by family members or loved ones.

9.1.1.3.2.1 Decomposed, Incinerated, Disfigured or Fragmented Remains

Jaw osteotomy/resection in such cases may facilitate dental charting and radiographic examination. Careful dissection of the incinerated head is required to preserve fragile tooth structure and jaws in situ. Photographs and radiographs should be made prior to manipulation of badly burned, fragile fragments. The use of a fixative agent to stabilize remains should be considered as necessary. Care should be taken to use stabilizing agents that will not degrade the remains. These agents should only be used after any necessary DNA extraction is completed.

9.1.1.3.2.1.2 Skeletonized Remains

Since the skull and mandible are readily separated from the remainder of the skeleton, osteotomy/resection of the mandible or maxilla is not required.

9.1.1.4 Surgical Exposure for Access to Oral Cavity

Although the surgical exposure of the hard and soft tissue of the maxilla and mandible via sectioning or resectioning may be necessary for full access to dental structures, this should only be performed with the approval of the coroner/medical examiner and according to the autopsy protocols of the local municipality. Consideration of the fact that family members may wish to exercise their right to view even the most severely decomposed or fragmented remains requires that this procedure only be utilized when no other alternative is available.

If adequate justification is found, surgical access to the oral cavity should be performed in a manner that minimizes the extent of surgical intervention and with the goal, whenever possible, to attempt to return the tissues to their original location following the examination. In those cases where this is not possible and in cases where the remains are not needed for additional examination, the resected section should be stored in the same human remains pouch as the rest of the remains.

9.1.1.4.1 Scientific Tools to Aid in Victim Identification

Numerous scientific tools are available with the ability to characterize the physical and chemical properties of dental material available to aid in victim identification.

9.1.1.4.1.1 Characterization of Dental Materials by Physical and Chemical Properties

Published studies by Bush (2007), have demonstrated that the microstructure and composition of classes of dental materials are distinct and specific to a manufacturer. This information can be used to aid in the confirmation of victim's identity. Composite resins and other dental materials contain filler particles and chemical forms of elements that are unaffected by extreme temperatures, even cremation. These are particularly well suited for this analysis. However, the utility of this approach depends on the manufacturer information being included in the antemortem records and the ability to obtain the composition information of these materials.

9.1.1.4.1.2 Methods Used to Analyze Dental Materials

Numerous systems and methods are available to analyze dental materials. These systems can be standardized using NIST traceable standards. Limitations include that a given tooth must be extracted and desiccated for analysis.

9.1.1.4.1.2.1 Scanning Electron Microscopy/ Energy Dispersive X-ray Spectroscopy (SEM/EDS).

SEM/EDS is a combination of tools that simultaneously provide quantitative microstructure and elemental composition information of a material. SEM provides structural detail while EDS provides information on

composition. Specific procedures on how to perform comparative SEM/EDS are available from the State University at Buffalo.

9.1.1.4.1.2.2 X-Ray Fluorescence (XRF)

In XRF, the same X-rays information is detected as in EDS. The difference is that trace levels of elements are detected which allows for fine distinction between composition of materials. Unlike EDS, there are no industry standards for the spectral data; therefore, comparative analysis is more difficult. However, local library data can be generated with a specific instrument

9.1.1.4.1.2.3 Visible light Fluorescence

Fluoresces occurs when a specific wavelength of light illuminates an object and a longer wavelength light is emitted. Fluorescing agents are sometimes added to composite resins and dental ceramics to enhance esthetics. The fluorescing of these material when tooth structure is illuminated by UV or near-UV light of 495-362nm will delineate the extent of a restorations if these materials were utilized. However, this process does not yield quantitative results that might be mapped to a specific material.

9.1.1.4.2 Ethical Considerations

The forensic odontologist has both the legal and ethical obligation to conduct a thorough postmortem examination of the decedent. As this can only be accomplished with proper access to the oral structures, in some cases it may require surgical exposure of the oral cavity regardless of community or family wishes. The forensic odontologist must take all steps necessary to minimize the disfigurement of the remains; however, ultimately, if no other alternative can be found and surgical access is required, the exposure must be adequate to allow for the proper documentation of all structures of the oral cavity.

9.1.1.4.3 Techniques for Dissection/Osteotomy/Resection

Various dissection/osteotomy/resection techniques existed to surgically access the oral cavity. The decision as to which method to employ should be done by a case –by-case basis. Prior to utilizing any techniques, proper permission of the ME/C should be granted. It is beyond the scope of this document to discuss individual techniques.

9.1.1.4.3.1 Preservation of Jaw Resection Evidence

The preservation of jaw resection may be indicated:

- In the event of an inability to adequately identify the remains and where future testing may be required;
- Remains are to be transferred, with proper authorization, to other facilities for additional examination and testing;
- Other valid justification for preservation of the jaw specimens.

In cases where preservation of evidence is required, proper permission of the ME/C must be granted and local regulations and requirements must be followed

9.2 The Postmortem Dental Record

While most morgues will have the standard autopsy equipment, the forensic odontologist may wish to assemble a forensic odontology autopsy kit that may include mouth mirrors, explorers, camera equipment, anatomic dental

charts, impression materials, mouth props, surgical access instruments, etc.

The postmortem dental examinations might utilize anatomic dental charts, photographs, radiographs, casts, tape recordings, and/or narrative descriptions. The data collected should be comprehensive in scope since antemortem records are commonly not discovered until days, weeks or even years later. Accordingly, the postmortem dental record will include all or most of the items given below:

1. Basic Data;
2. Case Number;
3. Date/Time;
4. Jurisdiction/Authority;
5. Location;
6. Putative ID, if any;
7. Body Description, General;
8. Approximate Age;
9. Ancestry;
10. Sex;
11. Condition;
12. Jaw Fragment(s) Description;
13. Any additional data that may aid in the identification.

9.3 Dental Examination

The universal tooth numbering system is currently used in the United States (see Section 10.3.1 Numbering Systems, Narrative Descriptors and Nomenclature below). The record should reflect any missing dental structures or jaw fragments as well as those present and available for evaluation. The chart should illustrate as graphically as possible the following

- Configuration of all dental restorations (including prostheses), caries, fractures, anomalies, abrasions, implants, erosions or other features for all teeth;
- Materials used in dental restorations and prosthetic devices, when known;
- Periodontal conditions, calculus, stain;
- Occlusal relationships, malposed teeth; anomalous, congenitally missing, and supernumerary teeth;
- Intraoral photographs should be used to show anatomic details of teeth, restorations, periodontium, occlusion, lesions, etc.

9.3.1 Numbering Systems, Narrative Descriptors and Nomenclature

The anatomic dental chart may be supplemented by a narrative description of the postmortem findings with particular emphasis on unusual or unique conditions. Standardized dental nomenclature should be used as described below.

9.3.2 Numbering Systems

The numbering system utilized should follow rules laid out in the tooth numbering section ANSI/ADA Standard 1058 -The Forensic Dental Data Set, as well as the tooth numbering section of the ADA CDT codes and ISO 3950-2015 Dentistry - Designation System for Teeth and Areas of the Oral Cavity. The 2015 update of the ISO standards specifically states, *"The tooth designation will be based on the anatomy of the tooth regardless of its location in the area of the mouth". This protocol should be utilized in cases of tooth numbering ambiguity regardless of the numbering system used.*

9.3.2.1 Universal Numbering System

The system of numbering teeth that is used in the United States. The teeth are numbered from 1 to 32. The upper right third molar is #1, the upper central incisors are #8 and #9, the upper left third molar #16, the lower left third molar #17, and the lower right third molar is #32. The universal tooth numbering system plus the actual name of the tooth should be used (e.g. tooth #3, upper right first permanent molar).

For deciduous teeth, the teeth are numbered A to T). The upper right deciduous second molar is #A, the upper deciduous central incisors are #E and #F, the upper left deciduous second molar #I, the lower left deciduous second molar #J, and the lower right deciduous second molar is #T. The universal tooth numbering system plus the actual name of the tooth should be used (e.g. tooth #A, upper right second deciduous molar).

9.3.2.2 The ISO Numbering System

Odontologists should be aware of the ISO Numbering System. This system is used throughout the developed world. Quadrants are numbered from 1 to 4. The upper right quadrant is 1, upper left 2, lower left 3, and lower right 4. Teeth are numbered from the midline to the posterior. Central incisors are #1, canines #3, and third molars #8. Teeth are represented by a two-digit code with the first number representing the quadrant and the second number representing the tooth. Thus, the upper left first molar is 26 (quadrant 2, tooth 6).

9.3.3 Dentition Descriptors and Tooth Surfaces

The coding of teeth using terms such as primary, permanent, and mixed dentition, mesial, occlusal, distal, facial, and lingual surfaces should follow the descriptor definition specified in ANSI/ADA Standard No. 1058- Forensic Dental Data Set. The coding utilized will be based on the needs of the dental provider, the software utilized and the requirements of the agency. Ideally, they should be translatable in ANSI-NIST ITL Type 12 Dental Data to allow for the electronic conveyance of the data.

9.4 Dental Impressions

Impressions should be considered when bitemarks, rugae patterns, or other evidence warrants the procedure.

9.4.1 Supplies and Equipment

Appropriate trays (plastic or metal) which can be modified to fit the mouth using alginate or other American Dental Association approved dental impression material. If acceptable to the ME/C and available, digital scans/digital impression technology can be utilized.

Type III dental stone is the material of choice for pouring casts. Plaster of Paris should not be used.

9.4.2 Dental Impressions and Fabrication of Casts

Two sets of impressions, both maxillary and mandibular, are obtained in the conventional manner. Casts should be trimmed and appropriately labeled with the case number and date.

9.5 Dental Radiology

Postmortem radiographs graphically complement the visual examination/charting of the oral and perioral structures and can provide significant data essential for identification (see Section 10.5 Dental Radiology above). In general, radiographs are required in cases where there is no putative ID, even if antemortem records have not yet been located and/or the jaws cannot be retained. Obviously, postmortem radiographs are required on all cases where comparative dental analysis is the prime method of identification, however, even if a non-dental putative ID is available, radiographs should be considered if there is a possibility that a secondary identification modality may be required in the future.

NOTE: All dental radiographs should have a distinct orientation indicator to assure unambiguous interpretation of the radiograph's orientation. All duplicate images should bear right and left notations.

9.5.1 Postmortem Radiographs

A comprehensive postmortem radiographic examination might include all or some of the following views, depending on the circumstances of the case.

9.5.1.1 Intraoral Radiographs

Conventional or Digital dental bitewing and periapical radiographs of the anterior and posterior teeth should be made in a consistent manner on each decedent (see Section 10.5.1.1 Intraoral Radiographs above).

Since a radiographic comparison of the antemortem to the postmortem radiographs can effect a positive dental identification, it is imperative that the highest quality postmortem images be obtained.

9.5.1.2 Teeth within the Alveolus

Digital or film dental bitewing and periapical radiographs of anterior and posterior teeth comparable to those taken antemortem. ("Bitewing" views need not be taken in the conventional manner with the teeth in occlusion; alternatively, the upper and lower teeth can be radiographed separately, but using a horizontal bitewing angulation not a periapical angulation).

9.5.1.2.1 Dental Fragments, Dissociated Teeth

Appropriate radiographs of all dental fragments, dissociated teeth, bone, and restorations should be obtained. Occlusal or lateral plate film may be used for objects larger than periapical film size.

9.5.1.2.2 Edentulous Areas

Periapical radiographs of edentulous arches or areas, especially the third molars, which may be impacted or previously extracted, are necessary. Periapical radiographs of sockets of teeth lost postmortem should be taken, since antemortem radiographs of these same teeth may be the only evidence that becomes available

9.5.1.2.3 Removable Dental Prostheses and Oral Appliances

Removable complete and partial dentures, oral orthopedic and orthodontic devices, mouth guards, bleaching splints may provide information to assist in the identification process, even without being labeled. The postmortem dental examination should carefully document such devices to compare to potential antemortem records.

For complete and partial dentures, antemortem dental laboratory records or the dental treatment record should document the brand, mold, type (acrylic or porcelain) of the denture teeth, along with information regarding the

denture base, including characteristics such as festooning, post dam, acrylic shade (clear, veined, color), palatal relief or any unusual characteristics to the denture.

For splints and other devices that cover the teeth there is the potential to use it as an impression of the teeth, so that it can be cast in dental stone and compared to an antemortem dental model. Transfer DNA on a removable dental prosthesis or appliance should be considered as a potential identifier in instances of commingling of remains.

9.5.1.3 Extraoral Radiographs

Extraoral radiographs (e.g., lateral jaw, maxillary or frontal sinus, and panoramic radiographs) are often useful.

10 FACTORS THAT ARE USEFUL FOR COMPARISON PURPOSES

Dental identifications are based on the matching of specific morphologic features, such as restorations, caries, present/missing teeth and /or prosthetic devices, and evidence of surgical interventions that are readily documented in the dental record. Given adequate records, a nearly infinite number of objective factors have identification value. Thus, objective findings, particularly those that are unique to the individual, provide the basis for concordance or exclusion. Concomitantly, apparent discrepancies between the antemortem and postmortem evidence (e.g. errors in recording, dental treatment subsequent to the available antemortem record) must be resolved.

There are numerous examples of objective findings in the teeth, periodontium, and/or jaws that may be demonstrable in both antemortem and postmortem records. The factors listed are by no means complete; however, they may serve as a checklist and demonstrate the range of objective findings that may be applicable in difficult identification cases.

It should be noted, however, that the decrease in caries incidence in recent years would dictate greater reliance on other dental findings in the future

10.1 Dental Features Useful in Identification

Teeth

- Teeth present, erupted, unerupted/impacted.

Missing Teeth

- Congenitally missing, lost antemortem, lost perimortem/postmortem.

Tooth Type

- Primary, permanent, and mixed dentition, retained primary teeth, supernumerary teeth.

Tooth Position

- Malposition, facial/lingual version, rotations, supra/infra positions, diastemata, adjacent marginal ridge height discrepancies, other occlusal discrepancies.

Crown Morphology

- Size and shape of crowns, enamel thickness, location of contact points, cemento-enamel junction, biologic affinity variations e.g. shovel-shaped incisors, carabelli cusp, etc.

Crown Pathology

- Caries, attrition/abrasion/erosion, coronectomy, atypical variations (e.g., peg laterals, fusion/generation, enamel pearls, multiple cusps, dens in dente, dentigerous cyst).

Root Morphology

- Size, shape, number, dilacerations, divergence of roots.

Root Pathology

- Root fracture, hypercementosis, cementoma, residual root fragments, external root resorption, root hemisections.

Pulp Chamber and Root Canal Morphology

- Size, shape, number, secondary dentin.

Pulp Chamber and Root Canal Space Pathology/Endodontic Therapy

- Pulp stones, dystrophic calcification, root canal therapy (e.g., gutta percha, silver points, endodontic paste and retrograde fill procedures, internal resorption, apicoectomy, periapical pathology, periapical abscess/granuloma/cyst, taurodontism, condensing osteitis).

Dental Restorations

- Metallic restorations: amalgams, gold, or non-precious metal crowns/inlays, endodontic posts, pins, fixed prostheses, implants.
- Non-metallic restorations: acrylics, silicates, composite resins, porcelain, etc., partial and complete removable prostheses.

Dental Restoration Morphology

- Shape and location of restorations, shape and location of line angles, shape and location of margins relative to anatomical structures, shape and location of margins relative to line angles, imperfections in restorations.

Periodontium/Gingival Morphology/Pathology

- Contour of gingival recession, focal/ diffuse enlargements, interproximal craters, inflammatory color changes, physiologic or pathologic pigmentations, metallic fragments, plaque and concretions, oral hygiene status, stains, calculus.

Periodontal Ligament Morphology/Pathology

- Thickness, widening (e.g., scleroderma), lateral periodontal cyst, alveolar process and lamina dura, height/contour/density of crestal bone, thickness of inter-radicular alveolar bone, exostoses, tori, pattern of lamina dura (loss, increased density), periodontal bone loss, trabecular bone pattern, osteoporosis, radio-densities.

Maxilla and Mandible Morphology/Anatomical Landmarks/Pathology

- Maxillary sinuses size, shape, retention cyst, antrolith, foreign bodies, oral-antral fistula, relationship to adjacent teeth, anterior nasal spine, incisive canal, median palatal suture, incisive canal size, shape, cysts, pterygoid hamulus size, shape, fracture, mandibular canal/mental foramen diameter, anomalous (bifurcated) canal, relationship to adjacent teeth, coronoid and condylar process size and shape, temporomandibular joint size, shape, hypertrophy/ atrophy, ankylosis, fracture, arthritic changes.

Other pathologic processes/jaw bones

- Developmental/ fissural cysts, hemorrhagic (traumatic) bone cyst, salivary gland depression, reactive/neoplastic lesions, metabolic bone disease, other disorders inducing focal or diffuse radiolucencies or radiopacities, evidence of orthognathic surgery, or prior evidence of trauma (e.g. wire sutures, surgical pins, etc.)

10.2 Criteria for Comparison

10.2.1 Basic Theory

All of the methods of human identification (visual, fingerprint, anthropologic/radiographic, DNA, and dental), involve the comparison of the antemortem data to postmortem evidence in order to establish a positive identification. The rationale for the forensic identification of deceased and living persons is because each person has a unique genotype, phenotype (except for monozygotic twins) as well as physical changes that occur during their lifetime, which can be compared to biometric data of the unidentified person.

For dental structures, discernable physical differences between individuals as well as the physical alteration of the dentition by a dental provider's intervention can be visualized with a complete physical and radiographic exam. The stability of these changes over time and the known direction of change that typically occurs to these structures (See Section 11.2.2 Direction of Change below) allows for the reliable dental comparison of biometric features and the identification of humans based on the uniqueness of these features.

10.2.2 Direction of Change

When there is an alteration in an individual's dental condition that direction of change is chronologically based in one direction. This was described by Lorton and Langley, "The direction of change of status of a tooth is fixed; that is a tooth cannot have a filling on a surface and then proceed to a state in which there is no filling on that surface. It can only go from having no filling on a surface to a state in which there is one." Extra care should be exercised when the comparison is between deciduous and succedaneous teeth.

Likewise, once a tooth is extracted or otherwise deemed missing, it cannot subsequently be present. This change is significant during the verification process and must be considered during any comparison or search process. Again, extra care should be taken when the comparison is between deciduous and succedaneous teeth.

The forensic odontologist will evaluate and compare the postmortem evidence and the antemortem materials. It is their task to determine if the two records were made or could have been made from the same individual. Most will employ similar routines and techniques; however, there may be variation in the method utilized for the actual comparison. For there to be a positive identification, all inconsistencies within the written records must be reconciled and distinguishing features must be demonstrable in the evidence

10.2.3 Points of Concordance

It has often been stated in forensic odontology literature that the comparison of dental features (see Section 11 Factors That Are Useful For Comparison Purposes above) does not require any specific number or minimum number of concordant points in order to declare a positive dental identification. It is commonly believed that even a singular unique feature may be enough in a particular instance to make an identification. However, there is little documented large-scale research to support this conclusion and the specific level of uniqueness of any specific feature has never been quantified.

In addition, a review of the literature from the 1980's and 1990's shows that the research that supports this assertion is based on very differing terminology. In order to define a minimum number of concordant points it is important to define the exact meaning of the term. Therefore, the following definitions will be used in this document:

10.2.3.1 Points of Concordance

In an attempt to clarify the meaning of concordant teeth and concordant points when describing points of “matching”, this document will use definitions outlined by Acharya and Taylor and others.

10.2.3.2 Concordant feature

This term includes any single characteristic of a tooth, restoration, associated anatomical structure or pathological process that has an individually distinct, biometrically measurable or describable characteristic.

As a rule, dental restorations have far more unique concordant features when compared to the number of unique morphological features on a natural tooth. Even a single restoration has multiple measurable metrics such as width, depth, and height as well as shape. Shape, too, has multiple metrics including line angles, imperfections, and location relative to anatomical structures.

Some caution should be exercised when quantifying any of these biometric parameters since anatomical structures as well as the shape and size of a restoration can be altered by the angulation of the radiograph and the superimposition of adjacent structures.

10.2.3.3 Concordance Points

Concordance points are points of matching between antemortem and postmortem data. They consist of two types.

Concordant Teeth

Concordant teeth are teeth in which multiple concordant features between antemortem and postmortem images or casts of teeth are noted and deemed identical with no irreconcilable discrepancies. For a sound (virgin) tooth, it would be multiple morphological structures. For a restored tooth, it would be morphological features as well as the additional restorative features. A tooth is considered a single concordant tooth regardless of the number of concordant features noted during the comparison of antemortem with postmortem. You have only a single concordant tooth once the antemortem and postmortem tooth is matched (there may have been multiple concordant morphological and/or restorative features noted, but the tooth represents a single concordant entity).

10.2.3.3.1 Concordant Characteristics

This term is used to describe any physiological, anatomical or pathological feature external to the tooth that has distinct concordant features. Examples include cysts, an amalgam tattoo, extraction socket, trabecular bone pattern, etc.

The documentation of uniqueness of anatomical structures has been even less well studied than the uniqueness of teeth. Bone trabeculation, pulpal anatomy, and root morphology, although unique, often do not rise to the level of uniqueness that allows for the unequivocal identification of an individual.

10.2.3.4 Minimum Points of Concordance

Early studies such as Keiser-Nielsen suggested the utilization of a minimum of 7 to 12 points of concordance to establish a match, similar to ridgeology (fingerprints). Acharya and Taylor showed that while “the incidence of positive identification was more frequent with a minimum of 12 concordant points” there were numerous cases where 12 or more concordant points failed to achieve a positive identification and that “identities were also confirmed in some cases using less than 12 points of correspondence”. They concluded that there is no basis for defining a minimum number of concordant points necessary before a positive identification can be made on dental evidence.

Some of the issues concerning studies describing the minimum number of points of concordance are as follows:

- Most studies measure the points of concordance (concordant teeth and/or concordant characteristics) and do not state the minimum number of concordant features that were required to make that determination.
- The degree of uniqueness of concordant features is not precisely defined. Uniqueness depends not only on the frequency within a population but also the population size of the data. In addition, it also depends on the bias of the observer. The "perceived uniqueness" of implants will not only vary with the socioeconomic status of the decedent population but may also vary based on the personal experiences of the forensic odontologist.
- Studies determining points of concordance do not state if secondary testing was done to confirm the identifications.

Studies do not state if the forensic odontologist was given any contextual information, which could have supported the identification even with a few points of concordance.

As a rule, dental identification should rely solely on the weight of the dental evidence. The use of supporting contextual evidence, although important, should only be used by the ME/C in making a final determination if the dental evidence is insufficient to make an absolute determination (see Section 11 Factors That Are Useful For Comparison Purposes above).

In summary, because of lack of double blind scientific studies concerning a minimum number of concordant points, as well as the minimum number of concordant features necessary to define a concordant point and the frequency of concordant features within a population, makes a clear minimum number of concordance points necessary for a comparative dental identification difficult to be defined. Given the high success rate of dental identifications, it is wise to follow the advice of Acharya and Taylor that "each case has its own individuality and should be treated as such."

10.3 Cognitive Bias And Serial Unmasking

Cognitive bias is a deviation in judgment created by preexisting perceptions of the individual examiner. These alterations in perception can originate from many sources, including personal biases, workplace pressures or even the introduction of external relevant or irrelevant data from the actual investigation. In the field of forensics, these biases can be particularly detrimental especially when qualitative judgements must be made and there is little quantitative studies to measure the uniqueness of particular trait. One method to reduce this is to provide the examiner with only the evidence needed to make a determination. Additional information can be provided, as needed, a process call serial unmasking, if the evidence is inconclusive or after a determination is made, in order to support or refute the findings.

10.4 Forensic Odontology and Other Forensic Biometric Data

Human identification by comparative dental analysis should ideally be based solely on the dental evidence. The presentation to the examiner of non-dental forensic biometric data prior to establishing and identification may result in cognitive biases influencing the determination. In the serial unmasking technique, only the minimal amount of information necessary to make a dental identification is supplied. This ensures the quality of the dental identification and minimizes cognitive bias influences. In addition, in cases where irreconcilable discrepancies of the data are exposed (i.e. conflicts in sex determination based on anthropological findings versus the dental records) the withholding of this evidence will serve as a quality control in the forensic identification process.

10.5 Contextual Evidence

Contextual evidence is information gathered from the setting of an event or object. In the holistic approach to identification, all available scientific and contextual evidence is provided to an examiner to facilitate an

identification. Similar to supplying other forensic biometric data (???) this approach could introduce cognitive biases particularly if the contextual evidence is extremely compelling. Additional contextual information using a serial unmasking technique (see above "Forensic Odontology and Other Forensic Biometric Data") may help make a definitive identification when each additional line of evidence is weighed and treated on its own merits. Therefore, in cases where there is insufficient dental evidence to firmly establish an identification contextual evidence such as the location of where the body was found, items of personal identification such as driver's licenses or passports, and identifying factors on the body, may be considered. Hopefully, when compelling, but not definitive dental evidence is present (i.e. insufficient points of concordance to fully support the identification) the combined use of this data may lead to a stronger conclusion. However, the evaluation of contextual evidence is based on a qualitative assessment, and not a quantitative assessment, of uniqueness and care must be exercised to prevent cognitive bias from influencing the significance of the contextual evidence. It is also crucial that the scale of the identification project is considered and the identification strategy adjusted accordingly. Finally, a protocol should be defined as to whether the forensic odontologist or other forensic specialists should determine the final identification.

Categories and Terminology for Body Identification

Numerous attempts by national and international agencies to define degrees of confidence concerning the level of concordance between dental records have been proposed. Current commonly used terminologies has been defined by numerous forensic odontology organizations, however no known documentation exists to compare the terminology utilized by different organizations as well as the terminology used by forensic odontologists with the terminology used in other forensic fields.

10.6 International Organization for Forensic Odonto-Stomatology (IOFOS)

Between 2004 and 2007, IOFOS recommendation for the classification of dental identification was posted at <http://www.odont.uio.no/foreninger/iofos/quality/Identification-IOFOS.htm>. Although the actual URL no longer exists, the historical website can be accessed at: <https://web.archive.org/web/20050104181346/http://www.odont.uio.no/foreninger/iofos/quality/Identification-IOFOS.htm>.

The IOFOS classification system consisted of three levels of certainty. Although the IOFOS system supplied quantitative guidelines to its terminology, it is uncertain how these metrics were determined. In addition, the extent to which the terminology was ever utilized and the current status of the classification system is unclear.

10.6.1 Identity established (IOFOS)

Less than 1:10,000 other persons may fit the details; this conclusion may stand alone as evidence of identity.

10.6.2 Identity possible (IOFOS)

More than 1:100 persons may fit the details; the conclusion needs to be supported by other strong evidence.

10.6.3 Identity probable (IOFOS)

The conclusion needs to be supported by other evidence.

10.7 The American Board of Forensic Odontology (ABFO)

The ABFO has also defined the categories of approved terminology to describe the levels of certainty for a dental identification. It is currently the terminology of choice in the United States. However, the definitions are qualitative

in nature not quantitative. As with the IOFOS, system there is no known documentation to compare the terminology utilized with the terminology used in other fields of forensics.

10.8 Positive Identification (ABFO)

The antemortem and postmortem data are concordant in sufficient detail to establish that they are from the same individual and there are no irreconcilable discrepancies.

10.9 Possible Identification (ABFO)

The antemortem and postmortem data have consistent features, but, due to the quality of either the postmortem remains or the antemortem evidence, it is not possible to confirm a dental identification.

10.10 Insufficient Evidence (ABFO)

The available information is insufficient to form a conclusion.

10.11 Exclusion (ABFO)

The antemortem and postmortem data are clearly irreconcilable. However, it should be understood that identification by exclusion is a valid technique in certain circumstances.

NOTE: Since, the forensic odontologist is not in a position to verify that the acquired `s are correct with regard to name, date, etc. the report should state that the conclusions are based on records that are purported to represent a particular individual.

11 Forensic Odontology Software Applications (FOSA)

In many cases, the dental identification of unknown human remains is a function of direct comparison of the postmortem dental records with the antemortem dental records of a suspected individual. A more difficult case scenario is the discovery of remains for whom a possible identity is not apparent. Evidence found at the scene or on the body can be useful to direct the investigation to a particular individual.

One of the more difficult tasks for a forensic odontologist is the identification of unidentified remains when the investigators have no clue to the possible (presumptive) identity. With computer comparison programs, the antemortem and postmortem information is entered into a database. Thousands of comparisons are made generating a ranking list of possible candidates that can then be confirmed or rejected by visual comparison of the appropriate dental radiographs and/or other dental evidence.

11.1 Minimum Software System Requirements

The concept of a computer database of dental information is not new; however, there are numerous issues that should be considered when selecting a "Search/Comparison" (FOSA) program.

- The computer software program must be easy to use and have the capability to perform general and specific searches and dental characteristic comparisons.
- The entry codes, forms, and procedures must be clear and uncomplicated for use by a forensic odontologist.
- Dental data should be peer-reviewed for quality assurance confirmation before data entry into the computer database.
- Law enforcement offices with authority to submit data must be educated concerning the use and value of the program.

- It should be mandatory that the dental data of all verified missing persons and unidentified remains or unidentified living individuals be collected and that data be entered into the local as well as state and or national dental comparison databases. This should become protocol for all law enforcement offices.

11.2 Coding Of Dental Data

11.2.1 Coding Philosophy

There are a few fundamentally different philosophies when it comes to recording of dental data in a forensic odontology software application. It is important that an organization clearly define its subscribed philosophy and educate its users to the implication of the differences as it related to coding dental records.

11.2.1.1 Coding as a Legal Record

This philosophy requires coding of teeth exactly as it has been noted in a dental record regardless of the consequences as it relates to aiding in matching the records. In cases of possible ambiguity (for instance multiple surfaces are recorded for what may appear as a single surface restoration), the dental chart becomes the final arbiter of the code. The advantage of this method is it creates an unambiguous method of interpreting the chart and creates a document solely based on outside data without introducing any biases from the inputting operator. The big disadvantage is that it may hinder the ability of the matching software algorithms to create an optimized ranking.

11.2.1.2 Coding as an Aide to Finding a Match

This philosophy requires coding of teeth in a way that optimizes the likelihood of finding a match. An example of this would be to code all orthodontically driven premolar extractions as the removal of the first premolars, regardless of the antemortem record, in order to allow the matching software to create a more realistic matching list. In cases of possible ambiguity, coding rules would take precedent and a more consistent method of coding between operators is likely. The advantage of this method is it creates a better ranking list but requires better training of the operator especially as it relates to matching algorithm rules. In addition, its use as a legal record in a court of law would require a more extensive explanation as to possible discrepancies in the forensic coding application and the submitted dental records.

11.2.1.3 Software Solutions

As forensic software packages improve, the need to define a coding philosophy should diminish. New packages take many of these ambiguity issues and correct them in their software code and in the matching algorithms, thereby mitigating some of the discrepancies that can be found in the legal record that affects comparison rankings.

11.2.2 Coding Granularity

Coding granularity is defined as the extent to which a coding system distinguishes a specific feature or entity. In forensic odontology, the most common example is whether to define a restored tooth with a simple "R", or to define the number of surfaces included in the restoration that, in the U.S, would be any combination of M, O, D, F, and L. The forensic coding of dental data falls into a wide range of granularity for the degrees of detail for almost all of its data. It is beyond the scope of this technical report to describe each system in detail but an understanding and overview of the advantages and disadvantages of each group is important.

11.2.3 Dental Coding, Ranking and Search Methodology

There are two basic methods used by FOSA to aid in matching dental data. The first method is to rank possible matches based on ranking algorithms, which compare records and find those that have the most similarities and fewest dissimilarities. A second method is a focused search wherein a unique pattern is found in a section of the mouth and the software is required to find other records with similar patterns.

Theoretically, the greater the number of codes compared, the higher the likelihood that a high number of similar matches (combined with the fewest number of dissimilar mismatches) will lead to an identification. For focused searches, this is especially true where unique features (i.e. a 5-rooted maxillary molar) can be sufficient to isolate a possible match. However, because dental data is not static and can change over time the higher coding granularity can lead to more dissimilarities as dental restorations are replaced or tooth loss occurs. A less granular coding system (defining teeth as filled and unfilled) may be better at ranking in cases where there has been a high degree of dental change and not a significant number of records. Less detailed coding also allows for less experienced operators to code teeth and can significantly accelerate the data entry process. However, a system of low granular coding can significantly limit the ability to perform focused searches because of its limitation in separating unique features.

Research in the early 2010's by Adams, Aschheim and others showed that the degree of data dilution could be mitigated when:

- The simplified codes are selected carefully;
- The matching algorithms are optimized for the simplified codes;
- The comparison size is moderately small (<1000 victims); and
- There is only a small amount of fragmentation of remains.

11.3 Coding Philosophy and Coding Granularity in Software Packages

As a rule, coding granularity is determined by the software application or database utilized. In addition, end users are trained in specific coding systems and any theoretical benefits gained by switching may be outweighed by the necessity to retrain individuals. However, the issue of granularity and coding philosophies must be considered when multiple teams utilizing multiple FOSA, with multiple coding philosophies need to integrate data. For complete information on forensic dental data transfer, (see Section 15.1.3 ANSI/NIST/ITL Standard below).

12 Currently Used Software Package

Numerous "search and match" software packages exist for dental data. Sometimes referred to as refer to as Forensic Odontology Software Applications (FOSA) only three software packages with dental identification modules are used within the US Government agencies including the U.S. Military.

12.1 WinID3

WinID3 is a Windows-based software, written in Visual Basic 6 / Microsoft Access. It was developed by Dr. James McGivney in the late 1990's. Unlike the other two packages, this software package only has a dental module and is not a full featured Forensic management system. Designed to run either on a single PC or on a simple Workgroup network, it has been used extensively in the United States for numerous multiple fatality incidents, including the World Trade Center, Hurricane Katrina, and the Joplin Tornadoes. Data is entered using primary codes similar to the NCIC dental coding system with optional secondary dental codes as well as free form comments. Data can be entered either by direct entry or via a clickable odontogram. The user is given numerous sorting option choices (Most Dental Hits, Least Dental Mis-matches, Most Restoration Hits, and Fuzzy Dental Logic) to create a ranked list of likely matches. The forensic odontologist then scrolls through that list to determine visually matches by

viewing both the antemortem and the postmortem odontograms. Ranking is based on Hits, Misses, Possible, and No information scoring. The current version includes a "bridge" with the DEXIS digital radiography application, which allows WinID3 to send demographic information to the radiography application. The software is available in English, French, German, Italian, Portuguese, and Spanish language editions. In 2014, the source code was assigned to the American Board of Forensic Odontology. WinID3 can be reviewed and downloaded on its website at <http://www.abfo.org/winid/>.

12.2 UVIS (Unified Victim Identification System) / UDIM (UVIS Dental Identification Module)

Following the September 11 World Trade Center attack the Department of Homeland Security funded the Office of Chief Medical Examiner of the City of New York (OCME) to develop a web browser-based application to handle critical fatality management functions made necessary by a major disaster. UVIS (Unified Victim Identification System) is an enterprise-level application designed to manage and coordinate all of the activities related to victim identification and missing persons reporting. Numerous modules covering areas such as the call center, case management, family assistance center, field operations, disaster mortuary management, disaster victim identification, identification tracking, postmortem, and remains storage. In addition, security features such as user rights, data security, and automated backup are included.

UDIM (UVIS Dental Identification Module) was developed by Dr. Kenneth Aschheim in conjunction with the forensic odontologists of OCME and the ICRA Sapphire Inc. (then a Trumbull, Connecticut-based consulting firm). As a Windows-based application, it is an integrated module in the UVIS – application. Utilizing a simple coding system as well as optional, user-editable, restoration codes, condition codes, and material codes, its "click to code" self-correcting interface, color-coded odontogram, and rich coding set allows for extensively detailed coding. Its jaw fragment management allows for the linking and joining of specimens, and Dexis integration allows for unlimited image importation. UDIM utilizes a single sorting algorithm based on explainable and unexplainable discrepancies and has some built in coding correcting algorithms to compensate for the most common ambiguities.

As an enterprise level application, the original UVIS/UDIM required both a dedicated web server and SQL server. As UVIS was designed as a disaster management package, familiarity with the software required constant training to maintain the user's expertise. In order to overcome this issue, in 2014 UVIS-Case Management System (UVIS-CMS) was released. Unlike UVIS, this application was designed for daily operation with a special "surge-mode" in the event of a large multi-fatality incident. By combining the functionality of the two operations into a single package, familiarity with the software was assured. The UDIM-application was also ported to allow for seamless integration. In 2015, OCME released UDIM-Stand Alone (UDIM-SA), a standalone version of UDIM. This version has identical features as UDIM/UVIS and UDIM-CMS with the additional capability of being deployable on a single PC or within a simple workgroup. The UDIM application and source code is available from the Department of Homeland Security. The UVIS/UDIM system can be reviewed on its website at <https://uvistraining.com/>. Free copies of the software can be obtained by contacting the New York City Office of The Chief Medical Examiner.

12.3 DVI System International

The DVI System International is a product of Plass Data Software and is the official software application for most INTERPOL DVI teams as well as members of North Atlantic Treaty Organization. Like UVIS, it is an enterprise level application multiple fatality management package with an integrated dental module. It utilizes a three letter mnemonically based coding system and is capable of displaying a detailed odontogram of even the most complex dental record. Complete integration of both paper and electronic data allows the system to work in any environment. In 2014, the Forensic Odontology Subcommittee of Interpol's DVI Steering Committee simplified the coding system in order to streamline data entry. As with the other two software applications described above, DVI

International creates a ranking of possible matches based on a proprietary ranking algorithm. The system is available in English, French, Spanish, Norwegian, Dutch, Swedish, Danish, and German languages. With constant upgrades, new capabilities are continually being added to the system. Unlike WinID and UDIM-SA, this is a paid commercial software package and does require a high level of expertise to install and operate. Information concerning the software and a trial package is available at <http://www.plass.dlk>.

12.4 OdontoSearch 3.0

In cases where antemortem radiographs are not available, comparative dental analysis comparisons can only be based on written notes and charts obtained from a missing individual's medical records. The problem with this data is that, unlike radiographs, the information cannot be exclusively correlated to a specific individual. Although absolute uniqueness cannot be determined, studies have shown that in large populations the frequency of certain restorative patterns are more "unique" than other patterns. The OdontoSearch 3.0 computer program (<http://www.odontosearch.com>) provides an objective means of assessing the frequency of occurrence of these dental restoration patterns. By comparing, an individual's pattern of missing, filled, and unrestored teeth to a large, representative sample of the U.S. population a likelihood of occurrence of this pattern (similar to mitochondrial DNA comparisons) is calculated. Often, this information, when combined with contextual information, is sufficient to determine an identification, especially in non-fragmented cases.

13 TRANSFER OF DENTAL DATA

13.1 Compatibility Among Software Packages

Digital biometric data refers to the digital representation of an individual's characteristic that can be used by a FOSA to help identify that individual. Different systems utilize different data formats to store that information. Although many similarities exist between systems, the coding of dental data between FOSA dental modules sometimes creates compatibility issues.

13.1.1 Transfer Dental Data – Coding Issues

There is no universally accepted coding system for dental forensic data. Although similarities exist between systems, different degrees of granularity can lead to the loss of some data in cases where lower granularity systems transfer data to a high granularity system. However, recent studies have shown that for most mass fatality incidents, especially those involving only a few hundred individuals, lower granularity data, sometimes known as simple coding can achieve excellent results when compared with high granularity systems using more complex detailed coding.

13.1.2 Transfer Dental Data – Security Issues

Local jurisdictional rules may require that a secured direct messaging system be utilized in order to secure the transfer of any digital information. As a rule, the transfer of dental data should follow identical rules specified for other forms of evidence by the local jurisdiction. If the transfer occurs between multiple jurisdictions, the rules of the more stringent jurisdiction should be followed. In some cases, federal rules may supersede those of local jurisdiction especially when the transfer is across state lines.

13.1.3 ANSI/NIST/ITL Standard

In 1986, in order to facilitate the effective exchange of forensic identity data across jurisdictional lines the government, the United States government, created the ANSI/NIST ITL Specification For The Data Format For The

Interchange Of Fingerprint, Facial, and Other Biometric Information. Known as ANSI/NIST-ITL, this specification has gone through numerous updates and in the 2013 update a standard for the transfer of forensic dental data, known as Type 12 data was created.

13.1.3.1 Record Type-12: Forensic Dental And Oral Record

The Type-12 record is used to exchange information concerning an individual's dental or oral characteristics. This specification currently uses the lexicon of ANSI/ADA Specification No. 1058 Forensic Dental Data Set for its intermediary dental data coding methodology; In addition, the specification outlines the XML format for the transfer of forensic dental data between software packages. The ANSI NIST ITL standard can be downloaded from http://www.nist.gov/itl/iad/ig/ansi_standard.cfm.

13.1.3.2 Record Type-10: Photographic Body Part Imagery

Type-12 Forensic Dental And Oral Record data are typically used in conjunction with images. Depending on the image type they can be either Type-10 intra-oral and extra-oral photographs or Type 22 Non-photographic imagery records (12.1.3.3 Record Type-22: Non-Photographic Imagery below). Type-10 image records contain 2D photographic imagery (i.e. Visible light photography) and related information. Textual and analytic information pertinent to the digitized image should also be transferred with these images. These images are typically sent by more common computer formats such as JPEG, TIF, Windows bitmaps, etc. however the use of RAW format is recommended when especially when chain of custody issues need to be addressed. In cases where local jurisdictional rules allow, annotation may be included on the image in order to preserve this information.

13.1.3.3 Record Type-22: Non-Photographic Imagery

Type-22 record data is utilized to convey dental radiographs and other related imagery useful in forensic dental procedures. Any nonvisible light image is considered a Type 12 record and should be utilized in lieu of a Type-10 record (such as infrared or X-ray). In addition, Type 12 records include 3-D imagery data, cone beam images, CAT Scans images etc. When a Type-22 record is transferred, it is important that the images transferred in the most commonly accepted file format for these images. Generally, the specification for the transfer of medical and dental imagery is Digital Imaging and Communications in Medicine (DICOM) standard. DICOM should be utilized whenever possible because it not only provides the transfer of images but also includes the corresponding metadata in which typically includes historical information concerning images.

Since most FOSA systems, unless paired with a Picture Archiving And Communication System (PACS), do not accept native DICOM images, the images need to be saved in a more traditional file format. If these file formats, such as JPEG, TIF, or other bitmap file format are utilized care should be taken in order to prevent degradation of the image. If local jurisdictional rules allow, proper annotation should be utilized on the image in order to minimize errors during the identification process. These images can be transferred in a manner similar to Record Type-

10 images (see Section 15.1.3.2 Record Type-10: Photographic Body Part Imagery above).

13.1.4 Dental Encoding Translator Applications Suite (DEnTAS)

In 2015, NIST introduced a “proof of concept” product known Dental Encoding Translator Applications Suite (DEnTAS) which utilizes the ANSI NIST ITL standard in order to demonstrate the translation of dental codes and

the exchange of antemortem and forensic dental data between software packages. The prototype program can be downloaded from NIST at <http://www.nist.gov/itl/iad/ig/odontology.cfm>

14 External Databases

Unlike ridgeology (fingerprints) with its AFIS (Automated Fingerprint Identification System) database, and DNA, with the CODIS (COmbined DNA Index System) in the United States there are only a limited number of small databases of dental data. Because of this limitation, a presumed identification is virtually always requisite for comparative dental analysis to be performed. However limited these databases may be, since they do exist, they should be utilized whenever possible.

14.1 NamUs

The National Missing and Unidentified Persons System database is an NIJ funded program administered by the University of North Texas. NamUs consists of the unidentified persons, missing persons (MUP), and unclaimed persons databases that are cross-referenced, allowing advanced search and comparison protocols. The system is internet based and allows the uploading and reviewing of images (radiographs, dental records, photos, etc.). Law enforcement, medical examiners/coroners, forensic specialists (odontologists, anthropologists, fingerprint examiners, etc.), and the public have various levels of access privilege to the system. It has been online since 2009 and has assisted hundreds of MUP identifications in the United States. More information is available at www.namus.gov.

14.2 NCIC

The FBI's National Crime Information Center, NCIC, contains approximately 13 million active records in 21 files, to help criminal justice professionals apprehend fugitives, locate missing persons, recover stolen property, etc. <https://www.fbi.gov/about-us/cjis/ncic> Three of the files are Missing Person, Wanted Person, and Unidentified Person. Criminal justice agencies enter records into NCIC. Those records become accessible to law enforcement agencies nationwide. The system can cross-reference files and respond instantly. NCIC also contains images that can be associated with records to help agencies identify people and property items. The National Dental Image/Information Repository (NDIR) within NCIC permits law enforcement agencies to store, access, and supplement dental records, dental x-rays, photographs, etc. to help facilitate the identification of Missing, Unidentified, and Wanted persons(<https://www.fbi.gov/foia/privacy-impact-assessments/ndir>).

14.2.1 Others

Numerous other organizations and websites have a limited amount of dental data. These too should be consulted when appropriate (see Section 9.3.10 Websites above).

15 VERIFICATION OF REMAINS PRIOR TO RELEASE

Prior to closing the human remains pouch (HRP) after an examination, the body identification (morgue reference number [MRN]) must be verified with the identifying number attached to the remains. Once the HRP is sealed, an identifying tag or label with the verified MRN should be affixed to the outside of the HRP. When the remains is authorized for release from the morgue, the identifying number on the HRP should be verified along with the decedent's name. Should a final verification be required, a visual exam of the dentition and comparison with the dental chart can be performed at the time of release.

16 DATA BACKUP

Digital data should be backed up on the local computer server of the ME/C, on at least one secure stand-alone backup hard drive and on secure off-site media or cloud storage. Hard copies of material that cannot be readily digitized should be maintained in the ME/C master file and security protocols in place for other types of physical evidence should be followed for these hard copies as well.

17 CLOUD STORAGE OF DATA

Traditionally, forensic data has been stored on a local server or a personal computer. Cloud storage of data is the use of remote hosting servers on the Internet to store, manage, and process this data. In addition, when the software to input, process and analyze this data is also on a remote server the applications with the data and is delivered over the network, the type of cloud computing is called Software as a Service or SaaS. Cloud computing raised additional issues for the forensic odontologist. These issues are covered in proposed ADA Technical Report No. 1091 Cloud Computing: Implications and Recommendations for Dental Practice.

18 DATA DISPOSITION GUIDELINES

Data acquired during the postmortem dental examination, antemortem records received, written reports, and any documented communications should be maintained by the ME/C in accordance with their protocol. The examining forensic odontologist may also retain copies of the data, if ME/C security protocols allows, in order to refer to the data should the need should arise.

However, if ME/C security protocols requires the ultimate destruction of the data it should be disposed of following approved data destruction protocols. Paper documents should be shredded using crosscut shredding devices. Electronic media should not be deleted but should be "wiped clean" utilizing specialized software. In addition, physical destruction of electronic media should be encouraged as an additional security measure.

18.1 DE-IDENTIFICATION OF DATA FOR RESEARCH AND EDUCATIONAL PURPOSES

There are currently no approved guidelines for the proper use or for de-identification of forensic dental data for research and educational purposes. Due to the sensitive nature of this data, extra care should be exercised in its use and consultation with the appropriate institutional review committees is strongly advised.

It has been suggested, that at minimum, federal HIPAA de-identification protocols for the Electronic Health Record should be followed prior to using this data. This includes the removal of all 18 HIPAA "Identifiers" of an Individual as listed at the government web site for "Guidance Regarding Methods for De-identification of Protected Health Information in Accordance with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule" at <http://www.hhs.gov/ocr/privacy/hipaa/understanding/coveredentities/De-identification/guidance.html>.

The following identifiers of the individual or of relatives, employers, or household members of the individual should be removed:

- Names
- All geographic subdivisions smaller than a state, including street address, city, county, precinct, ZIP code, and their equivalent geocodes, except for the initial three digits of the ZIP code if, according to the current publicly available data from the Bureau of the Census:
 - The geographic unit formed by combining all ZIP codes with the same three initial digits contains more than 20,000 people; and
 - The initial three digits of a ZIP code for all such geographic units containing 20,000 or fewer people is changed to 000.

- All elements of dates (except year) for dates that are directly related to an individual, including birth date, admission date, discharge date, death date, and all ages over 89 and all elements of dates (including year) indicative of such age, except that such ages and elements may be aggregated into a single category of age 90 or older;
- Telephone numbers;
- Fax numbers;
- Email addresses;
- Social security numbers;
- Medical record numbers;
- Health plan beneficiary numbers;
- Account numbers;
- Certificate/license numbers;
- Vehicle identifiers and serial numbers, including license plate numbers;
- Device identifiers and serial numbers;
- Web Universal Resource Locators (URLs);
- Internet Protocol (IP) addresses;
- Biometric identifiers, including finger and voice prints;
- Full-face photographs and any comparable images;
- Any other unique identifying number, characteristic, or code.

Researchers must also consider that some multiple fatality incidents have relatively few fatalities. Therefore even eliminating all 18 elements identifiers would still allow for the possibility of re-identification of the decedents. In those cases, additional aggregation of data must be considered to de-identify individuals further.

18.2 Disposition of Radiographs

Like other forms of digital data, digital radiographs should be backed up both for on-site as well as off-site media or cloud storage media. If photographic (film) media was utilized to image remains, double pack intraoral film is recommended. One set of images should be retained by the forensic odontologist for his case file. The second set may be mounted and forwarded with a written report to the medical examiner/coroner for the master file. Digital radiographs should be backed up in the same manner as other digital media.

19 Quality Assurance (QA)

It is vital that protocols be in place to assure the quality of the forensic odontology identification process. Numerous methods are available and the degree of utilization will often depend on the resources of the local community. The use of a second forensic odontologist to confirm the identification, or the use of a secondary method of verification such as DNA should be considered, at least on a sampling basis, to ensure the integrity of the process. Currently, there are no firm scientifically established recommended guidelines for forensic odontology quality assurance. Therefore, it is recommended that the local municipality utilize guidelines established for its other forensics specialties (i.e. DNA and ridgeology). For mass a fatality incident, it is strongly recommended that both a forensic odontology review board, as well as a multi-specialty supervising review board, be established to confirm all identifications findings.

20 CONCLUSION

The consequences of a misidentification can have emotional and legal ramifications well beyond a specific case. Thus, using the proper method and procedure for such method(s) of human identification is of the utmost importance. Dental identification is the most common method of identifying human remains that are decomposed, burned, fragmented, or skeletonized. This identification is accomplished by conducting a thorough postmortem dental examination, the collection of antemortem dental and medical records, and the comparison of the postmortem evidence with the antemortem record. It is imperative that the proper procedures be followed and that meticulous attention is paid to the detail of the postmortem examination and comparison to the antemortem dental record.

Annex A

(Informative)

Abbreviations Used In This Document

Scope

This annex describes the abbreviation used in this document.

ABFO - American Board of Forensic Odontology

ADA - American Dental Association

AFIS - Automated fingerprint identification system

ANSI - American National Standards Institute

ASC - ANSI Accredited Standards Committee

ASD - ANSI Accredited Standards Development Organization

ASFO - American Society of Forensic Odontology

BAFO - British Association of Forensic Odontology

CODIS - Combined DNA Index System

CT - Computerized tomography

CBCT - Cone beam computed tomography

DICOM - Digital Imaging and Communications In Medicine

DMORT - Disaster Mortuary Operational Response Team

EDR - Electronic Dental Record

FOSA - Forensic odontology software application

HIPAA - Health Insurance Portability and Accountability Act

IOFOS - International Organization for Forensic Odonto-Stomatology

IR - Interventional radiology

ISO - International Organization for Standardization

ME- /C Medical Examiner or Coroner

MUP - Missing unidentified persons

mtDNA - mitochondrial DNA

MRN - Morgue reference number

NamUS - National Unidentified Persons System

NIDR - National Dental Image/Information Repository

NIST - National Institute of Standards and Technology

NCIC - National Crime Information Center

OCME - Office of Chief Medical Examiner of the City of New York

OSAC - Organization of Scientific Area Committees

PCR - Polymerase chain reaction amplification

STR - Short tandem repeat typing.

PA skull -(Caldwell view) a caudally angled posterior anterior radiograph

PSP - Phosphor storage plate

RAW - uncompressed image format

SAC - Scientific area committee

SCDI - ADA Standards Committee on Dental Informatics

TIFF - Tagged Image File Format

UDIM - UVIS dental identification module

UVIS - Unified Victim Identification System

UVIS-CMS - UVIS case management system

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