

American Board of Forensic Odontology

Diplomates Reference Manual

Section IV Standards & Guidelines

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American Board of Forensic Odontology, Inc.

DIPLOMATES REFERENCE MANUAL

SECTION IV STANDARDS & GUIDELINES

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SECTION IV

Standards & Guidelines

Definitions of Guidelines, Standards and Policies

Guidelines:

- Suggested but not mandatory
- Recommended, but not required

Standards:

- A model to be followed; establishes protocol; a benchmark
- Strictly defined and to be followed by all based on its correctness
- Compulsory minimal level of practice
- More restrictive than guidelines; more enforceable

COMMENT: a failure to follow a standard may be defensible if it can be justified by proof that the standard is not worthy or that the departure is equivalent.

Policy:

- A predetermined, selected and planned prescription of conduct.
- Policies define beliefs and philosophy
- A principle, plan, or course of action as pursued by an organization

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AMERICAN BOARD OF FORENSIC ODONTOLOGY (ABFO)

Standards and Guidelines for Evaluating Bitemarks

Revised 2-19-2018

Preface

ABFO standards and guidelines are dynamic and can be modified in response to developments in the field following ABFO policies and bylaws. These standards and guidelines were developed with consideration of the current status of the discipline. The appendices to this document include a glossary of terms (Appendix 1), factors influencing the interpretation of bitemarks on skin

(Appendix 2), lists of potential uses of bite mark evidence (Appendix 3), and checklists for specific procedures (Appendices 4, 5, and 6).

These Standards and Guidelines are not intended to be contrary to any jurisdiction's laws and statutes.

1. Standards

- a. An ABFO Diplomate shall be familiar with and adhere to ABFO Standards.
- b. An ABFO Diplomate shall document, review, and consider all evidence received and collected.
- c. An ABFO Diplomate shall be familiar with the current literature, and use established analytical methods for pattern, patterned injury, and bite mark evidence. These can be supplemented with other techniques or methods.
- d. Final reports shall include the results of all analyses.
- e. Terms used in a manner different from the guidelines shall be explained in reports and in testimony.
- f. An ABFO Diplomate shall not express conclusions unconditionally linking a bite mark to a dentition.
- g. An ABFO Diplomate shall not give expert testimony outside her/his recognized area(s) of expertise.

2. Guidelines

a. Guiding Principles

i. Objectivity (see Appendix 1)

Odontologists should remain objective in all phases of investigation, analysis, comparison, and reporting of their casework, including minimizing all forms of bias.

ii. Nature, Value, and Limitations of Bite Mark Evidence

Odontologists should discuss and explain the nature, value, and limitations of bite mark evidence with investigative and legal authorities involved, including the relationship of the bite mark evidence to the presence or absence of other physical evidence.

iii. Blinding

- 1) Whenever possible, the same odontologist should not collect evidence from both persons with patterned injuries purported to be bite marks and persons of interest whose dentitions may or may not have caused

the bitemark. Another dentist should be engaged to collect such evidence in order to minimize bias.

- 2) When only one person of interest is proffered, the odontologist should engage another dentist to produce a “dental line-up” of dentition evidence. If utilized, the dental line-up evidence should include evidence from the person or persons of interest and from other individuals as foils. (see Foil in Appendix 1)
 - a) The dental line-up evidence should be similarly produced, developed, and presented to avoid disclosing identifying information.
 - b) There should be no gross discrepancies in the general arrangement and number of teeth present for selected foils.
- 3) When multiple persons of interest are proffered, the odontologist should include one or more foils to supplement the dental line-up.
- 4) When comparing dentition evidence and bitemark evidence, the odontologist making the comparison should not have access to dentition information disclosing the identity of a person of interest. All comparison dentition evidence within the dental line-ups should be anonymized.

iv. Independent Verification

- 1) Before submitting a final report, odontologists should seek independent verification in the form of a second opinion from a minimum of one ABFO Diplomat.
- 2) Odontologists engaged for independent verifications should be blinded to the conclusions of the referring odontologist and blinded to information that would reveal identifying information regarding persons of interest.

b. Terms indicating a pattern or patterned injury is or is not a bitemark

i. Human Bitemark – human teeth caused the pattern

Criteria:

- 1) The pattern demonstrates class characteristics of human teeth, including prosthetic replacements when present.
- 2) The discernable features are sufficient such that other causes for the pattern were considered unlikely or excluded.
- 3) A curvilinear pattern or patterned injury generally circular or oval and often consisting of two opposing arches that may or may not be

separated at their bases by unmarked space. Sometimes only one arch is clearly visible.

- 4) Individual marks, impressions, abrasions, contusions, striations, or lacerations from specific teeth may be found within the pattern.
- 5) A central area of contusion is sometimes present.
- 6) In severe human bite marks, material may be forcefully removed from the medium bitten.
- 7) The marks present reflect the size, shape, arrangement, and distribution of the contacting surfaces of teeth. (The contacting surfaces of human teeth include the incisal and occlusal surfaces of teeth and may also include the lingual surfaces of anterior teeth.)
- 8) Some marks made by individual teeth can be recognized and identified based on the class characteristics and location relative to other features.
- 9) The size and shape of each visible arch conforms to the varying ranges of size and shape of the human dentition.

ii. Not a Human Bite Mark – human teeth did not cause the pattern.

Criteria: The pattern or patterned injury does not include features demonstrating the class characteristics of human teeth.

iii. Inconclusive – There is insufficient information available to support a conclusion of whether or not a pattern or patterned injury is a human bite mark.

Criteria: Features demonstrating the class characteristics of human teeth are incomplete, distorted, or otherwise insufficient.

c. Terms relating or linking a dentition to a human bite mark

i. Excluded as Having Made the Bite Mark

Criteria: The bite mark demonstrates class characteristics or individual characteristics that could not have been caused by the dentition.

ii. Not Excluded as Having Made the Bite Mark

Criteria: The bite mark demonstrates class characteristics or class and individual characteristics that could have been caused by the dentition. There are no unexplainable discrepancies between the features of the bite mark and the dentition. The dentition is not excluded from the population of dentitions that could have caused the bite mark.

iii. Inconclusive

Criteria: There is insufficient information to support a conclusion whether or not the bite mark could have been caused by the dentition.

d. Bite mark: Definition, Characteristics, and Evidentiary Value

i. Bite mark definition

A physical alteration or representative pattern recorded in a medium caused by the contact of the teeth of a human or animal. (see 2.b.1. *supra* for a comprehensive definition of a human bite mark)

ii. Characteristics of human bite marks

1) Class characteristic

A feature, trait, shape, or array that distinguishes a bite mark from other patterns or patterned injuries. An expected finding within a class or group.

2) Individual characteristic

A feature, trait, shape, or array that represents an individual variation within a group rather than an expected finding within that group.

a) Arch characteristic

An arch characteristic is a type of individual characteristic that is displayed in a pattern representing the arrangement of multiple teeth in a dentition or bite mark. (e.g. arch shape, arch size, rotated teeth, teeth displaced toward the facial or lingual, teeth drifted toward the mesial or distal, diastemata).

b) Dental characteristic

A dental characteristic is a type of individual characteristic seen in a bite mark that represents an individual tooth variation (e.g. wear pattern, chips, notches, fractures, dental anomalies).

iii. Evidentiary value of human bite marks

1) General considerations:

- a) After a pattern or patterned injury has been determined to be a human bite mark, an odontologist should evaluate the information in the bite mark for forensic significance or evidentiary value. The evidentiary value of the information should be determined to be sufficient before initiating comparisons to dentitions (see criteria at iv.2 *infra*).

- b) Induced distortion of the skin from biting action and other factors related to the nature of human skin can affect the recording of the dental features, arch size, and arch shape in the bitemark.
- c) Certain factors influence the interpretation of bitemarks on human skin. (see Appendix 2)

2) Criteria for Determining Evidentiary Value

Conditions and features of bitemark evidence that indicate sufficient evidentiary value for comparisons to dentitions include but are not limited to these criteria:

- a) The bitemark pattern was adequately photographed both without and with a reference scale a) in place, and b) on the same plane as the pattern or injury. (Note: Image management software cannot correct for deficiencies in this criterion.)
- b) Images used for comparison are properly focused, adequately illuminated, suitably exposed, and made with the plane of the image receptor either a) parallel to the plane of the portion of the bitemark being imaged, or b) not parallel to the portion of the bitemark being imaged but the images can be corrected for the angle known as theta (θ) using image-management software.

(see Theta (θ) in Appendix 1)
- d) Either the maxillary or mandibular arch or both arches can be located and the midline of one or both arches can be determined.
- e) Some marks caused by individual teeth can be seen and recognized based on their class characteristics and/or location relative to other features.
- f) The size and shape of each arch conforms to the variations of the size and shape of the human dentition.

e. Bitemarks made by Permanent, Mixed, and Primary Dentitions

- i. The criteria used to distinguish bitemarks made by an adult's teeth *versus* bitemarks made by a child's teeth should be based not on size alone, but also on the differences of the class characteristics of the permanent dentition and the primary dentition. Class characteristic features should be visible in the bitemark.

Bitemarks made by children and adolescents during their mixed dentition phase may exhibit characteristics of permanent and primary dentitions.

3. Linkage Terminology

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The ABFO standards and guidelines indicate that if sufficient information is available to support conclusions, bite mark linkage conclusions should only a) exclude or b) not exclude (*include*) a dentition. The specific terms found in 2.c. are: a) for exclusion, Excluded as Having Made the Bite mark, and b) for inclusion, Not Excluded as Having Made the Bite mark. Stronger terms of attribution are not condoned by the ABFO (see Standard 1.f.)

The following guidelines sections comprise the Best Practices for evidence collection, analysis, comparison and reports. Best Practices should be followed by odontologists whenever possible and practical.

4. Evidence Collection

From Questioned Patterns, Patterned Injuries, Bitemarks, Persons of Interest, and Dentitions

a. General considerations

- i. A questioned bitemark is a pattern or patterned injury that may or may not be a bitemark.
- ii. A dentition or subject dentition refers to the teeth of a known person of interest that may or may not have caused a bitemark.
- iii. The odontologist who collects the evidence from a questioned pattern, patterned injury, or bitemark should not also collect evidence from the dentitions of known persons of interest (see 2.a.iii.1).
- iv. If only one person of interest is proffered, then a line-up of dentition evidence from persons of interest and foils should be employed. (see Foil in Appendix 1) Foils should be persons unrelated to the case but with similar dentitions. (see 2.a.iii.2).
- v. An odontologist performing comparisons should be blinded to the identities of persons of interest and their dentitions (see 2.a.iii.4)
- vi. Evaluation of bitemark evidence includes:
 - 1) Examination of questioned patterns and patterned injuries to form conclusions, if the evidence allows, of whether or not they are bitemarks
 - 2) Interpretation and analysis of those questioned patterns or patterned injuries that are concluded to be bitemarks
 - 3) Comparison of evidence from bitemarks containing sufficient evidentiary value to evidence from subject and foil dentitions, and
 - 4) Formation of opinions, if the evidence allows, of whether a bitemark is excluded or not excluded as being caused by the subject and foil dentitions
- vii. Following evidence-based evaluation and analysis and if the evidence is sufficient, comparisons of bitemarks to subject and foil dentitions can be undertaken. These steps should follow established guidelines. Together they constitute a forensic physical comparison.

- viii. Because bite mark evidence evaluations, analyses, and comparisons fall within the knowledge spectrum described in state and federal rules of evidence as “scientific, technical, or other specialized knowledge that can be helpful to the court,” the admissibility of bite mark evidence in a legal proceeding is a determination made solely by the court.

b. Case information

- i. Case agency, case number, and date of examination should be noted and can also appear on the reference scale utilized for photographs.
- ii. The names of subjects should be recorded, if available, as well as the place of examination. However, information produced for blinded second opinions or independent verifications of conclusions should omit names or other identifying information
- iii. The medical or legal authority that requested or provided authorization for the odontology examination should be documented.

c. Chain of custody

- i. Receipt of any evidence by the odontologist should be clearly documented using appropriate chain of custody, including the case name and number, time and date of delivery, an inventory of the evidence delivered, and from whom the evidence was received, along with the recipient’s signature.
- ii. Release of evidence by the odontologist should be similarly documented.
- iii. A copy of the chain of custody should be retained as part of the case record.
- iv. The odontologist should place his/her mark and date of examination on each item of physical evidence, such as dental casts, CDs, DVDs, photographs, etc. in a non-diagnostic area using a method that does not materially alter the item or evidence.

d. Evidence collection from questioned bite marks

- i. General considerations
 - 1) In the context of this section the terms questioned bite mark, pattern, and patterned injury can be used interchangeably.
 - 2) Initial evidence collection from a questioned bite mark can be a one-time event without the possibility of a follow-up examination. When the odontologist is involved in the initial examination, collection of evidence from the site(s) should include the methods of documentation described below.

- 3) Evidence that was collected by others may be provided. Odontologists should assess such evidence and proceed only if the forensic significance or evidentiary value of the evidence justifies continuing the analysis.
- 4) Legal permission in the form of a written consent, search warrant, subpoena, or court order should be obtained from the appropriate authority prior to investigative procedures and should be noted in the reports.

ii. Documentation

1) General descriptors

- a) Case agency
- b) Case number
- c) Examiner
- d) Age, sex, and race of bite mark recipient

2) Pattern location

- a) Anatomical location of patterned injuries
- b) Surface contour
- c) Tissue characteristics
- d) Object (medium) description, if not human skin

3) Pattern or injury features

- a) Size
- b) Shape
- c) Nature (abrasion, contusion, laceration, avulsion)
- d) Other (indentations, incisions, unusual features)

4) Pattern description

- a) Orientation of maxillary/mandibular dental arches
- b) Locations of midlines
- c) Individual tooth marks
- d) Unmarked areas
- e) Tooth rotations, translations or anomalies
- f) Summary

iii. Orientation photographs

Prior to other evidence collection procedures, orientation images should be exposed to document the identity of the object or person, case information, and clearly demonstrate the location(s) of the questioned bite marks.

iv. Swabbing

If not already accomplished, each questioned bite mark should be swabbed for biological evidence following the proper protocols for the jurisdiction.

v. Photography

- 1) Under normal circumstances the pattern or patterned injury should be photographed using a high quality digital camera. Whenever possible the photographic procedures should be performed by or under the direction of the forensic odontologist.
- 2) Once the orientation images have been exposed as recommended in 5.d.iii. progressively closer photographs should be sequentially exposed of each questioned bite mark.
- 3) Images should be of sufficient resolution to allow for enlargement to life-sized dimension without pixilation.
- 4) Photographs of the pattern or patterned injury should be exposed without and with a properly placed and labeled reference scale (e.g. ABFO No.2[®] or similar).
- 5) In some cases, it can be beneficial to obtain serial photographs of the patterned injury over time.
- 6) Both ambient and artificial lighting can be used, as well as infrared (IR), reflective ultraviolet (UVA), and alternate light source (ALS) imaging when indicated.
- 7) Video imaging can be used *in addition* to conventional still photography.

vi. Impressions

- 1) Impressions should be taken of the surface containing questioned bite marks, especially when three-dimensional properties are present. The impression materials used should meet American Dental Association (ADA) specifications and should be documented by name, including lot number and expiration date, in the report.
- 2) Impressions should be taken of the dentition of a person with a questioned bite mark to assess the possibility of a self-inflicted bite mark. Or, in case the person with the questioned bite mark may have bitten another person that was involved in the incident.
 - a) Adequate support should be provided for the impression material.
 - b) Impressions should be poured with appropriate ADA listed materials following the manufacturer's directions. The resulting casts should be labeled and stored following appropriate chain of custody.

- vii. Checklist – A checklist for Evidence Collection from Questioned Bitemarks is at Appendix 4

- e. Evidence collection from persons of interest

- i. General Considerations

- 1) Subject dentitions are the teeth of persons of interest.
 - 2) Prior to collecting evidence from persons of interest, the odontologist should ensure that a written search warrant, court order, or other legal consent has been obtained from the appropriate authority, or the subject person in the case of informed consent.
 - 3) Court documents or consent as in 2) above provide legal authority for the collection of the evidence listed below. Copies of these documents should be retained as part of the case record.
 - 4) Whenever practical, the odontologist who collects the evidence from a questioned bitemark should not also collect evidence from the dentitions of persons of interest. An exception exists if, in the judgment of the odontologist, a questioned bitemark could have been self-inflicted. In these cases, the odontologist should also collect evidence from that person's dentition.
 - 5) Similarly, whenever practical, a second odontologist or another dentist should collect evidence from persons of interest following the guidelines below.
 - 6) If only one person of interest is proffered, in order to produce a dental line-up a second odontologist or dentist should collect or provide evidence from other individuals who are foils with similar dentitions to the person of interest.

- ii. Evidence collected should include:

- 1) Demographic and other identifying information
 - 2) Dental treatment records, if available

- iii. Photography

- To the extent possible, photographic documentation should include:

- 1) Extraoral photographs
 - 2) Full face
 - 3) Right and left three-quarter profiles
 - 4) Right and left full profiles
 - 5) Intraoral photographs (with retractors and mirrors as needed):
 - a) Anterior view with teeth closed

- b) Anterior view with teeth slightly parted
 - c) Anterior view with mandible protruded
 - d) Anterior view demonstrating maximal opening
 - i) with reference scale
 - ii) without reference scale
 - e) Lateral views, both left and right sides
 - f) Occlusal views of each arch
 - g) Additional photographs that may provide useful information
 - h) Images of surfaces of test bites with and without reference scales
- 6) Video imaging can be used *in addition to* conventional still photography

iv. Intraoral examination

The dentist performing the intraoral examination should document the condition of the teeth, including the following:

- 1) Missing teeth
- 2) Fractured teeth
- 3) Mobile teeth
- 4) Condition of the periodontium
- 5) Maxillary and mandibular tori
- 6) Tongue and lip piercings and/or jewelry
- 7) Other unusual intraoral features or anomalies

v. Impressions

- 1) Maxillary and mandibular impressions should be taken. Both conventional and digital impression techniques utilized in clinical dentistry are acceptable.
- 2) For conventional impressions, ADA-listed materials should be used following established dental impression techniques. Dental casts should be produced from impressions following established techniques.
- 3) For digital impressions ADA-listed optical scanner and laser scanner techniques are acceptable.
 - a) The digital files from the scans can be used for digital analyses utilizing appropriate software techniques.
 - b) Alternately, the digital files can be used following established techniques to produce physical dental casts
- 4) If removable prostheses are present, impressions should be made both with and without the prosthetic appliances *in situ*.
- 5) The inter-occlusal relationship should be recorded using ADA-listed materials and techniques.

- vi. Sample or test bites should be recorded using ADA-listed materials and appropriate techniques. These items should be labeled, photographed, and retained.
- vii. Dental casts
 - 1) If physical casts from either conventional or digital impressions are produced, master casts should be prepared. For master casts produced from conventional impressions, ADA-listed Type III dental stone prepared according to manufacturer's instructions should be used following established dental techniques. Master casts may also be made from digital files from digital 3D scans using fit for purpose ADA-listed materials.
 - 2) Additional casts can be poured from polyvinylsiloxane or polyether impressions or fabricated from digital files. Each subsequent model poured should be sequentially labeled to indicate the order of production.
 - 3) If the original conventional impressions are taken using alginate or similar materials, duplicate casts can be produced from an impression of the master cast made using ADA-listed materials for duplication.
 - 4) Duplicate casts should be appropriately labeled and the master cast utilized to produce the duplicate should be noted.
 - 5) Master casts should not be altered. All tests and experiments should be performed using duplicate casts.

viii. Other evidence

Upon request, additional reference samples can be collected and stored with appropriate authorization and following established protocols.

- f. A checklist for dentition evidence collection is at Appendix 5

5. Bitemark Analysis

a. General considerations

- i. Bitemark analysis in the context of this section refers to the analysis of patterns or patterned injuries that may or may not be bitemarks, as well as the continued analysis of patterns or patterned injuries that in the opinion of the odontologist are bitemarks.
- ii. Once an odontologist forms an opinion that a pattern is a human bitemark, the odontologist should complete the analyses of that bitemark before making any comparisons to the dentitions of persons of interest.

- iii. Comprehension of dental and oro-facial anatomy and morphology, plus an understanding of dental treatment modalities, are required for evaluation and interpretation of a pattern or patterned injury caused by human teeth.
- b. Interpretation of a Pattern or Patterned Injury as a Bitemark
 - i. Assessment of a pattern
 - 1) Determining the orientation of the marks caused by maxillary and/or mandibular teeth. The relative size and morphological differences visible in the pattern may support differentiation between marks from the maxillary and mandibular arches. Assessments may include, but are not limited to:
 - a) Locating within the marks the position(s) of the midline(s) of the maxillary and/or mandibular arches. Midline(s) of the maxillary and mandibular arches may be determined either by noting the central incisors visible in the mark, or by determining the midpoint of each arch.
 - b) Locating marks caused by specific teeth by examining the anatomical morphology of the incisal edge and occlusal surface patterns.
 - c) Locating areas without marks potentially due to missing, fractured, unerupted, partially erupted, malformed, or ectopic teeth.
 - d) Locating features that indicate rotations, translations, or other anomalies caused by specific teeth.
 - e) Performing a manual or computer-assisted metric analysis of the overall and specific features of the questioned bitemark.
 - f) Locating drag marks (e.g. abrasions, striations) in relation to specific teeth induced by motion during the act of biting.
 - 2) Summarize the features that form the pattern including:
 - a) Class characteristics of:
 - i) Primary dentition
 - ii) Mixed dentition
 - iii) Permanent dentition
 - b) Individual characteristics
 - i) Individual arch characteristics
 - ii) Individual dental characteristics
 - c) Anomalies or other unusual features

3) Form conclusion

ii. Graphic aids

Odontologists can use graphic aids to assist in the analyses or to demonstrate features of a questioned bitemark. For example, a software program can be used to optimize an image or to create demonstrative graphics.

c. Conclusions and Opinions

Following completion of the bitemark analyses, conclusions should be made following ABFO terminology guidelines (see 2.b and 2.c). A list of features that support the conclusion(s) should be included.

6. Bitemark Comparisons

a. General considerations

- i. An unknown exhibit (i.e. questioned bitemark), for which the odontologist is attempting to identify the origin, should be compared to the known reference exhibit(s) (i.e. dentition evidence).
- ii. Only patterns and patterned injuries that the odontologist has concluded are human bitemarks should be compared to the dentitions of persons of interest.
- iii. Patterns and patterned injuries the odontologist has concluded are animal bites can be compared to the dentitions of animals of interest.
- iv. Bitemark analyses should be completed before comparisons to dentitions are undertaken.
- v. To the greatest extent possible, odontologists should be blinded to information about the dentition evidence that would disclose the identity of a person of interest.
- vi. Whenever possible, a second odontologist or other dentist should collect the dentition evidence from persons of interest and from foils and then provide that evidence in a manner that allows odontologists performing comparisons to be blinded to the source.
- vii. Bitemark comparison conclusions are odontologists' opinions derived from evaluations and analyses based on education, training, knowledge, skill, and experience.
- viii. An odontologist should recognize that many human dentitions are similar and that bitemarks are not always accurately recorded in human skin. Opinions that exclude or do not exclude persons of interest should only be made in

cases in which information is sufficiently clear and distinctive to allow those opinions.

b. Methods of comparison

i. Overlays

- 1) Overlays are tools useful for comparing a dentition to a pattern or patterned injury determined to be a bitemark. Overlays can be hollow volume, solid volume, semi-transparent, or other representations of the biting surfaces of subject or foil dentitions.
- 2) Overlays can be computer generated from 2D or 3D scans of the subject or foil dentitions, 2D photographic images of the teeth or dental casts or 2D or 3D scans of dental casts.
- 3) Odontologists should confirm that the overlays and the images to which they will be compared are identically sized.

ii. Test bites

- 1) Test bites are made by producing simulated bites in a medium using dental casts. The medium used for the test bites can be dental wax or other ADA-listed dental materials, animal skin, human skin, or other media. Test bites can be made in more than one medium.
- 2) Test bites can be used to produce overlays. The overlays can be manually or computer generated and compared to or superimposed over same-sized images of the bitemark.
- 3) Test bites can be useful to analyze similarities or differences between the test bites and the bitemark. Analyses can be completed side-by-side or utilizing an overlay technique.

iii. Additional comparison techniques may include, but are not limited to:

- 1) Exemplars of the subject's dentition compared to corresponding-sized images of the bite pattern
- 2) Life-sized casts of subject's dentition compared to life-sized images or 3D casts of bitemark patterns
- 3) Manual or computer-generated comparisons
- 4) Digitization and computer enhancement of images
- 5) Use of computer software to assist in performing comparisons
- 6) Stereomicroscopy

7) Scanning Electron Microscopy

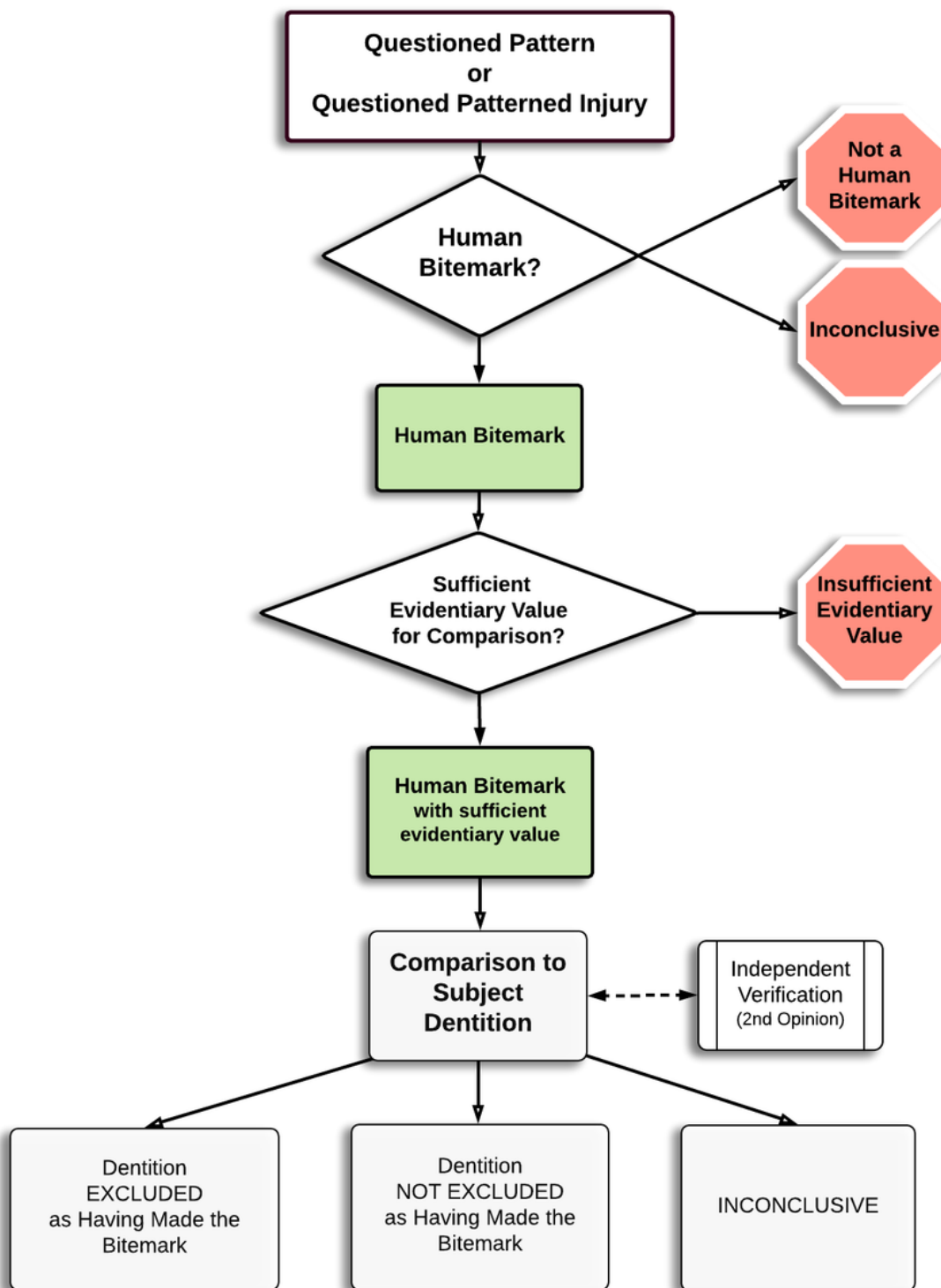
c. Conclusions

Conclusions should be expressed following ABFO Standards and Guidelines. A list of features supporting conclusions should be included.

d. ABFO Bitemark Analysis and Comparison Algorithm

The algorithm is intended as a graphic aid to odontologists. See following page.

ABFO Bitemark Analysis and Comparison Algorithm



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7. Bitemark Evidence Reports

- a. General considerations
 - i. The guidelines below apply generally to preliminary, interim, and final reports.
- b. Independent verification
 - i. An odontologist investigating a human bitemark case should seek independent verification in the form of a second opinion from a minimum of one ABFO Diplomate before submitting a final report. (see 2.a.iv).
 - ii. A second opinion checklist is at Appendix 6
- c. Components of bitemark evidence reports may include:
 - i. Introduction – Background information for the case. For example, what was requested, by whom, when requested, and why the request was made.
 - ii. Inventory of evidence received – Evidence submitted to the odontologist, including how and when acquired.
 - iii. Inventory of evidence collected – Type, source, and authority for evidence collected by the odontologist, evidence collected, official exhibit number assigned to the items of evidence collected, collection location, and date and time custody of each exhibit was accepted.
 - iv. Findings regarding pattern – Opinion stated using ABFO terminology.
 - v. Analysis – Methods employed, including the times and dates when the analyses took place.
 - vi. Results – Outcomes of analyses and comparisons.
 - vii. Conclusion – Conclusions and opinions of the relationship between each bitemark and dentition using ABFO terminology (see 2.b). Only one term of conclusion should be used for each comparison.
 - viii. Disclaimer – Optional statements can be included to convey that the opinion(s) are based on the evidence examined. For example, the odontologist can reserve the right to file subsequent reports should other evidence become available.

8. Appendices

Appendix 1 – Glossary of Terms

Appendix 2 – Factors Influencing the Interpretation of Bitemarks on Human Skin

Appendix 3 – Uses of Bitemark Evidence

Appendix 4 – Checklist for Evidence Collection from Questioned Bitemarks

Appendix 5 – Checklist for Evidence Collection from Dentitions of Persons of Interest

Appendix 6 – Checklist for Second Opinions in Bitemark Evidence Cases

APPENDIX 1

Glossary of Terms Used in Standards and Guidelines

Bite mark (*bite mark* and *bite-mark* are also acceptable forms)

- A physical alteration with a representative pattern that is registered in a medium caused by the contact of the teeth of a human or animal

Class Characteristic

- A general characteristic that defines a category of items or objects but alone is insufficient to establish identity
- A feature, trait, or pattern that distinguishes the human dentition from other items or objects or the dentitions of animals
- A feature, trait, or pattern that distinguishes a bite mark from other patterned injuries

Dental Prosthesis

- An artificial replacement of one or more teeth and/or associated structures

Dentition

- The teeth in the dental arches

Excluded

- In relation to bite mark evidence, a subject or foil dentition that is eliminated as having caused a bite mark

Exemplar

- A demonstrative example or model of an item or object(s)
- In bite mark evidence comparisons, exemplars are used to demonstrate the shape, size and position of the biting surfaces of the dentition

Foil

- In the context of a dental line-up for bite mark evidence comparisons, an individual or evidence from an individual that is not a person of interest but rather a distractor

Guideline

- An item, action, or level of practice or conduct that is recommended or suggested but not mandatory

Individual Characteristic

- A characteristic caused by intentional, unintentional, or accidental changes during use, development, etc. that are exceptional and can be used to individualize or identify a specific item or object
- A feature, trait, or pattern that represents an individual variation rather than an expected finding within a defined class or group

Not Excluded

- In bite mark evidence comparisons, a dentition that cannot be eliminated from having caused a bite mark

- The dentition is included in the population of dentitions that could have caused the bitemark
- Results of a comparison that determines the absence of unexplainable discrepancies

Objective

- Developing and maintaining neutral and unbiased attitudes, approaches, and opinions that are based on the available evidence

Pattern

- A distinctive shape, form or array
- In the context of bitemark evidence, a distinctive shape, form or array that appears in or on tissue or in or on a medium other than tissue

Patterned Injury

- An injury in tissue with distinctive shape, form or array indicating the characteristics of the contacting surfaces of the object(s) that caused the injury

Perimortem

- Occurring at or about the time of death

Person of interest

- An individual or subject who may or may not be associated with an event
- In the context of bitemark evidence, an individual or subject who had or may have had access to an individual who received a bitemark during a specified time interval

Shall

- The referenced item, action, or proscription is mandatory

Should

- The referenced item, action, or proscription is recommended

Standard

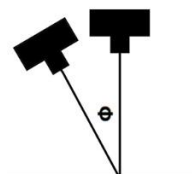
- A compulsory (i.e. mandatory) item, action, or level of practice or conduct

Subject Dentition

- The teeth of a person of interest that may or may not have caused a bitemark

Theta (θ)

- In the context of pattern or patterned injury evidence photography, when an image is recorded with the plane of the image receptor not parallel to the portion of the pattern being imaged, theta (θ) is the angle between an imaginary line perpendicular to the image receptor plane extended to a point on the surface imaged and an imaginary perpendicular line from an optimally placed camera's image receptor plane extended to that same point



APPENDIX 2

Factors Influencing the Interpretation of Bitemarks on Human Skin

1. Human skin factors
 - a. Type
 - b. Thickness
 - c. Pigmentation
 - d. Nature of underlying tissues
 - e. Viscoelasticity
 - f. Anisotropy (orientation to skin tension lines)
 - g. Hysteresis (short term only)
 - h. Vital response to injury
2. Injury factors
 - a. Contusion
 - b. Abrasion
 - c. Laceration
 - d. Incision
 - e. Avulsion
3. Biting dynamics factors
 - a. Movement during biting by person biting or person bitten
 - b. Force of the bite
 - c. Positional changes during and after biting
4. Age of the person bitten
 - a. Properties of human skin can change with age
 - b. Skin of older persons can respond to trauma with varying degrees of contusion, abrasion, laceration, and other effects
 - c. Skin of older persons can heal differently compared to the skin of younger persons
5. Health of the person bitten
 - a. Systemic diseases can affect the response of skin to trauma
 - b. Effects or side effects of medications can affect the response of human skin to traumas
6. Other
 - a. Healing process changes in bitemarks on living subjects. Examples:
 - i. Edema presence, progression, and resolution
 - ii. Contusion presence, progression, and resolution
 - iii. Scab formation and resolution
 - iv. Scars, fibrosis, and permanent skin changes
 - b. Postmortem changes in bitemarks on deceased subjects

APPENDIX 3

Uses of Bitemark Evidence

Bitemark evidence may be used to:

1. Document aspects of violence
2. Provide a profile of the dentition of a person of interest
3. Compare information from bitemarks to subject or foil dentitions
4. Provide a potential physical and temporal link between a recipient of a pattern or patterned injury and the dentition of the perpetrator
5. Support or refute the history of events that is reported by individuals in a legal proceeding
6. Further potential uses (from Silver, W.E., Souviron, R.R. (2009). *Dental Autopsy*. Boca Rotan, FL: CRC Press.):
 - a. A bitemark can indicate the infliction of pain
 - b. Bitemarks can be offensive, defensive, or consensual
 - c. Bitemarks usually indicate acts of violence
 - d. A bitemark can cause permanent injury; for example, avulsion of an ear, finger, nose or other body part
 - e. Bitemarks of high evidentiary value with distinctive markings can yield clues about the dentition of the questioned dentition – even in the absence of a formal comparison
 - f. Bitemarks in different stages of healing can indicate episodic infliction of injuries or abuse over time
 - g. Absence of any vital skin reaction (e.g. hemorrhage, swelling, etc.) can be indicative of a bitemark caused following death
 - h. Relative positions of the participants in violence involving bitemarks can vary. The location and orientation of bitemarks can provide odontologists with clues to interpret the dynamic interchange
 - i. Anatomical locations of some bitemarks indicate that the bitemarks could not have been self-inflicted
 - j. Presence of a bitemark should prompt medical personnel or members of the death investigation team to collect salivary evidence

APPENDIX 4

Checklist for Evidence Collection from Questioned Bitemarks

1. Initial Steps

a. Case data documentation

i. Identification data

- ☐ Case agency
- ☐ Case number
- ☐ Examiner

ii. Pattern location data

- ☐ Anatomical location
- ☐ Surface contour
- ☐ Tissue characteristics
- ☐ Object (medium) description, if not human skin

iii. Pattern or patterned injury features data

- ☐ Size
- ☐ Shape
- ☐ Nature (abrasion, contusion, laceration, avulsion)
- ☐ Other (3D features, indentations, incisions, unusual features)

iv. Pattern description data

- ☐ Orientation of maxillary/mandibular dental arches (if visible)
- ☐ Locations of midlines (if visible)
- ☐ Individual tooth marks
- ☐ Unmarked areas
- ☐ Features indicating tooth rotations, translations, or anomalies
- ☐ Summary of overall features

b. Orientation photographs

- ☐ Orientation images exposed prior to other evidence collection to document characteristics of the person or object, the case number and date, and anatomical location(s)

c. Swabbing

- ☐ If not completed by other investigators, each bitemark swabbed for DNA following proper protocols for the jurisdiction. If there is no jurisdictional protocol, the double-swab method is used

2. Photography

- ☐ High-quality digital camera used. Photographic procedures are performed by or under the direction of the forensic odontologist
- ☐ Appropriate ambient or artificial lighting (or both) utilized

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- ☐ Overall orientation images then progressively closer images exposed of each bitemark
- ☐ Images of sufficient resolution for enlargement to life-size without pixilation
- ☐ Photographs exposed without and with a properly placed and labeled ABFO No.2© or similar reference scale
 - ☐ Reference scale is a) in the same plane as, and b) adjacent to the portion of the pattern or patterned injury being imaged
 - ☐ Camera sensor and lens face are parallel to both the plane of the reference scale and the plane of the pattern being imaged
 - ☐ On curved or compound curved surfaces, multiple images are exposed with the camera sensor, lens face, reference scale, and the pattern in the same plane
- ☐ For a living person or person recently deceased, sequential photographs of the injury over time

When indicated, in addition to conventional visible light photographs, ☐ Infrared (IR), ☐ Ultraviolet (UVA), or ☐ Alternative Light Source (ALS) images are exposed

- ☐ Video imaging *in addition* to conventional still photography as indicated

3. Impressions

- ☐ Impressions of the surface containing the pattern or patterned injury when 3D properties are present using ADA-listed materials and named in the report, including lot number and expiry date
- ☐ Impressions of the dentition of the person with the bitemark to assess possibility of self-inflicted bite or to determine if they may have also bitten another person
- ☐ Suitable support provided for the impression material
- ☐ Impressions are poured using manufacturer's instructions and casts are labeled and retained following appropriate chain of custody

4. Chain of Custody

- ☐ Evidence received, collected or developed is clearly documented using appropriate chain of custody showing the case name and number, time and date of delivery, an inventory of the evidence delivered, and from whom the evidence was received along with his/her signature
- ☐ Similarly document any release of evidence by the odontologist

APPENDIX 5

Checklist for Evidence Collection from Dentitions of Persons of Interest

1. General Considerations

- ☐ Ensure appropriate search warrant, court order, or legal consent has been obtained
- ☐ Copies of these documents are retained as part of the case record
- ☐ Impressions of the dentition of the person with the bitemark to assess possibility of self-inflicted bite or to determine if they may have also bitten another person
- ☐ Another dentist collects dental evidence from persons of interest and foils. Blinded exemplars are provided to the odontologist for analysis but identities of persons contributing exemplars are not released.

2. Evidence Collected Should Include

- ☐ Demographic and other information specific to the subject
- ☐ Dental treatment records, if available

Photographs – to the greatest extent possible, photo documentation includes:

A. Extraoral photographs

- ☐ Full face
- ☐ Right and left three-quarter profiles
- ☐ Right and left profiles

B. Intraoral photographs (with retractors and mirrors as needed)

- ☐ Anterior view with teeth closed
- ☐ Anterior view with teeth slightly parted
- ☐ Anterior view with mandible protruded
- ☐ Anterior view demonstrating maximal opening
 - ☐ With reference scale
 - ☐ Without reference scale

- ☐ Lateral views, both right and left sides
- ☐ Occlusal views of each arch

C. Additional images

- ☐ Maxillary and mandibular surfaces of test bites with and without reference scale
- ☐ Video imaging in addition to conventional still photography as indicated

Intraoral examination

A. Condition of the teeth

- ☐ Missing teeth
- ☐ Fractured teeth
- ☐ Mobile teeth

B. ☐ Condition of the periodontium

C. ☐ Presence of maxillary and/or mandibular tori

D. ☐ Presence of tongue and/or lip piercings and jewelry

E. ☐ Other unusual intraoral features or anomalies

Impressions

- ☐ Maxillary and mandibular impressions taken with ADA-listed materials using appropriate dental impression materials

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- ☐ If removable prostheses are present, impressions made both with and without the prosthetic appliances *in situ*
- ☐ Inter-occlusal relationship recorded using approved materials and techniques
- ☐ Alternate impressions using approved intraoral 3D scanners as needed
- ☐ Sample or test bites recorded using appropriate ADA-listed materials and techniques, and these records photographed and retained

Dental casts

- ☐ Master casts prepared from impressions using ADA-approved Type III dental stone following manufacturer's instructions and accepted techniques.
- ☐ Master casts may also be made using approved materials from 3D scans as needed.

Swabbing

- ☐ If not completed by other investigators, buccal swabs should be collected and stored following established protocols

APPENDIX 6
Checklist for Second Opinions in Bitemark Evidence Cases

1. Case identifiers
 - ☐ Name and/or identifier recorded of person or object bitten
 - ☐ Notation of dentitions of persons of interest and foils blinded
 - ☐ Status of recipient of patterned injury noted
 - ☐ Alive when injury occurred and alive when evidence collected
 - ☐ Alive when injury occurred and deceased when evidence collected
 - ☐ Deceased when injury occurred
2. Requesting agency
 - ☐ Name of agency noted
 - ☐ Case contact person and title at agency noted
 - ☐ Date of retention noted
 - ☐ Chain of custody documented
3. Dates
 - ☐ Date questioned bitemark made noted, if known
 - ☐ Date of initial evidence collection procedures noted
 - ☐ Dates of additional evidence collection procedures noted
4. Examination and documentation of questioned bitemark
 - ☐ Date, Place, & Time of examination noted
 - ☐ Others present at examination noted
 - ☐ Other experts or consultants used noted
 - Description of the bitemark
 - ☐ Anatomic location of mark noted
 - ☐ Size and shape of mark noted
 - ☐ Type of tissue involved or type of medium if not human tissue noted
 - ☐ Documentation (photographic and other) appropriate for the nature of the injury
 - ☐ Exceptions noted in case specific comments below
 - ☐ ABFO terminology used to describe whether or not the pattern is a bitemark
 - ☐ Evidentiary value considered to support proceeding to comparison of bitemark(s)
 - ☐ Dentition cast acquisition and production techniques documented
 - ☐ Dental line-up utilized
 - ☐ Approved comparison technique(s) used
 - ☐ Other comparison techniques used
 - ☐ ABFO linkage terms used
 - ☐ Appropriate blinding procedures used
 - ☐ Second opinion written report produced following ABFO report writing guidelines

Case specific comments:

ABFO BODY IDENTIFICATION INFORMATION

The importance of timely identification

In the United States, the Medical Examiner or Coroner (ME/C) has the statutory responsibility and judicial authority to identify the deceased. The identification of unidentified living individuals is the responsibility of local, state or federal law enforcement agencies. 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.

Scientific Identification

All methods of identification involve comparing antemortem data to postmortem evidence. Although a presumed identification is often established by contextual evidence, ideally, antemortem biometric data of the individual should be obtained and compared to the postmortem evidence to establish a scientific identification. Currently there are five general methods used to identify deceased human remains of which most require a presumptive identification in order to allow for the direct comparison of antemortem and postmortem biometric evidence. The five methods of identification are visual, fingerprint, DNA analysis, anthropologic/radiology and dental comparison.

Visual

A non-scientific method, but 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 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 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 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.

Ridgeology (Fingerprints)

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 required a presumptive identification in order to obtain antemortem information.

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.

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.

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.

Though an individual's dental characteristics will often change during life (dental disease, restorations, extractions, etc.), changes after death are very slow. In fact, the dental condition at death has been shown to last in some cases for centuries.

When there is an alteration in an individual's dental condition that change is 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".

Likewise, once a tooth is extracted or otherwise missing, it cannot subsequently be present. This unidirectional change is significant during the verification process and must be considered during any comparison/search process

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 forensic odontologist will evaluate and compare the two dental records, the postmortem and the antemortem material. It is their task to determine if the two records were made or could have been made from the same individual. Though most will employ similar techniques and routines, there can be some variation in the way that this comparison is executed. In the end however, for there to be a positive match all inconsistencies within the written records must be explained and distinguishing features must be demonstrable in the hard material evidence, i.e. radiographs, dental models, photographs, etc.

Body Identification Guidelines

OUTLINE

I. Collection and Preservation of Postmortem Dental Evidence:

- A. The Remains - Examination Procedures
- B. Photography
- C. Jaw Resection
- D. Techniques for Dissection/Resection
- E. The Postmortem Dental Record
 - 1. Dental Examination
 - 2. Narrative Description and Nomenclature
 - 3. Dental Impressions
 - 4. Dental Radiology

II. Sources for Antemortem Data:

- A. Local Agencies
- B. State Agencies
- C. Federal Agencies
- D. International Resources
- E. Insurance Carriers
- F. Other Sources

III. Comparison of Antemortem and Postmortem Evidence:

- A. Dental features useful in identification

IV. Categories and Terminology for Body Identification:

- A. Positive Identification
- B. Possible Identification
- C. Insufficient Evidence
- D. Exclusion

Some diplomates may follow alternative techniques that may be equally effective. It is not the purpose of these guidelines to invalidate other methods, but rather to describe methods that a majority of investigators employ.

I. COLLECTION AND PRESERVATION OF POSTMORTEM DENTAL EVIDENCE

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 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).

A. Examination Procedures

1. Visually identifiable body

- Photographs, radiographs, dental charting
- Dental Impressions, as applicable
- Resection by infra-mandibular dissection

2. Decomposed/incinerated body

- Photographs, radiographs, dental charting
- Resection and preservation of jaw specimens, if indicated

3. Skeletonized remains

- Photographs, radiographs, dental charting
- Preservation of jaw specimens, if indicated

B. 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 #2™ right angle ruler is recommended. The photographs should be clearly labeled with the case number/name and date. All relevant photographic information should be documented.

1. Recommended Equipment

- Single lens reflex digital or 35 mm. film based camera
- Electronic flash (preferably point flash or ring light system)
- Cheek retractors
- Intra oral front-surface mirrors

2. Film based photography

- Color film (slide and/or print format)
- Black and white film, as required

3. Photographic Views

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

C. Jaw Section/Resection

Facial dissection and/or jaw sectioning/resectioning, which may be necessary for full access to dental structures are done only with approval of the coroner/medical examiner. Ordinarily, the circumstances dictating decisions to resect are applicable as follows:

1. Viewable Bodies

Restricted opening due to rigor may require:

Intra oral incision of masticatory muscles, with or without fracture of the condyles

Breaking the rigor with bilateral leverage on the jaws in the retromolar regions

Waiting until the rigor subsides

Infra-mandibular dissection with or without mandibular resection

Removal of the larynx and tongue at autopsy may facilitate the visual examination of the teeth and/or placement of intra oral films. Again, the removal of these tissues should only be performed after the autopsy and with permission of the pathologist.

These tissues should either be retained by the pathologist or replaced with the body.

2. Decomposed, Incinerated, or Fragmented Bodies

Jaw resection in such cases facilitates dental charting and radiographic examination.

Careful dissection of the incinerated head, in particular, is required to preserve fragile tooth structure and jaws in situ. Radiographs should be made prior to manipulation of badly burned fragments. Mechanical (or chemical) sterilization of such tissue should be instituted where necessary.

3. Skeletonized Remains

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

4. Preservation of Evidence

Jaw resection may be indicated in cases in which:

Body parts are to be transferred, with proper authorization, to other facilities for additional examination and testing.

A homicide victim is to be cremated.

There is other valid justification for preservation of the jaw specimens (state mandated law).

D. Techniques for Dissection/Resection

Selected techniques are described below. Other methods may be employed when indicated.

1. Facial Dissection:

Bilateral incisions of the face, beginning at the oral commissures and extending posteriorly to the anterior ramus, permit reflection of the soft tissues for better access.

Infra-mandibular Approach: Bilateral incisions are made across the upper anterior neck and extend to points posterior and inferior to the ears. The skin and underlying tissues are then reflected upward over the lower face thereby exposing the mandible.

2. Jaw Resection:

Stryker Autopsy Saw Method:

The soft tissue and muscle attachments on the lateral aspect of the mandible are dissected away by incisions which extend through the muco-buccal fold to the lower border of the mandible. Lingual attachments are similarly incised to include the internal pterygoid attachments to medial aspect of the rami and the masseter attachments on the lateral aspect. On the maxilla, facial attachments are incised high on the malar processes

and superior to the anterior nasal spine. Stryker saw cuts are made high on the rami to avoid possible impacted third molars. Alternatively, the mandible may also be removed by disarticulation at the temporomandibular joints. Bony cuts on the maxilla are made high on the malar processes and above the anterior nasal spine to avoid the apices of the maxillary teeth. A surgical mallet and chisel inserted in the Stryker saw cuts in the malar processes and above the anterior nasal spine are used to complete the separation of the maxilla. Remaining soft tissues in the soft palate and fauces are then dissected free.

Mallet and Chisel Method:

A mallet and chisel can be used to induce a “Le Fort” Type I fracture of the maxilla. The chisel blows are made below the zygomatic arch, high on the maxillary sinus walls bilaterally. Since it is virtually impossible to fracture the mandibular rami with the mallet and chisel, the mandible can be disarticulated at the temporomandibular joint in such cases.

Pruning Shears Method:

An alternative technique for resection of the jaws involves the use of large pruning shears. The soft tissue/muscle dissections are as described on page 10. The small blade of the pruning shears is placed within the nares and forced back into the maxillary sinus. A cut is then made along a plane superior to the apices of the maxillary teeth bilaterally. The mandibular bone cuts are performed by inserting the small blade of the shears high on the lingual aspect of the ramus near the coronoid notch bilaterally.

E. The Postmortem Dental Record:

While most morgues will have the standard autopsy equipment, the forensic odontologist may wish to assemble their own forensic kit to include mouth mirrors, explorers, camera equipment, anatomic dental charts, impression materials, cyanoacrylate, etc. Postmortem dental examinations might utilize anatomic dental charts, photographs, radiographs, models, 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 post-mortem dental record will include all or most of the items given below.

1. Basic Data:

Case Number
Date/time,
jurisdiction/authority
Location
Putative ID, if any

2. Body Description, General

Approximate age
Race, sex,
condition

3. Jaw Fragment(s) Description

F. Dental Examination:

The universal tooth numbering system should be used. 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:

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

G. Narrative Description 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 follows:

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 maxillary right third molar is #1, the maxillary central incisors are #8 and #9, the maxillary left third molar #16, the mandibular left third molar #17 and the mandibular right third molar is #32. The universal tooth numbering system plus the actual name of the tooth should be used (e.g. tooth #3, maxillary right first permanent molar)

2. Dentition Type and Tooth Surfaces

Primary, permanent, supernumerary, and mixed dentition. Mesial, Occlusal, Distal, Facial and Lingual surfaces (MODFL).

3. Prosthetics and other Appliances

-**Crowns:** full, 3/4, 7/8, or onlay coverage restorations.

-**Prosthetics:** Partial, full, or fixed dentures. Orthodontic bands, brackets, appliances, space maintainers and retainers. Mouth guards and night guards.

4. The FDI Numbering System

Odontologists should be aware of the FDI/ISO system of numbering teeth. This system is used throughout much of the world other than the United States. Quadrants are numbered from 1 to 4. The maxillary right quadrant is 1, maxillary left 2, mandibular left 3 and mandibular 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 quadrant first and the tooth second. Thus, the maxillary left first molar is 26 (pronounced 2-6).

H. Dental Impressions

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

1. Supplies and Equipment:

Appropriate trays, plastic or metal, which can be modified to fit the mouth
Alginate or other American Dental Association approved dental impression material. Type III dental stone is the material of choice for pouring models. Plaster of Paris should not be used.

2. Impressions and Preparation of Models:

Two sets of impressions, both maxillary and mandibular, are obtained in the conventional manner. Models should be trimmed and appropriately labeled with the case number and date. Also it is important to note that dental impressions on autopsy tables take longer to set.

I. 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 III). In general, radiographs are required in cases where there is no putative ID, antemortem records have not yet been located and/or the jaws cannot be retained. Postmortem radiographs must be considered the prime method of identification. A comprehensive postmortem radiographic examination might include all or some of the following views, depending on the circumstances of the case.

1. Intra oral Radiographs

Digital or analog dental bitewing and periapical radiographs of anterior and posterior teeth comparable in technique to those taken antemortem. (Bitewing views should be taken in the conventional “teeth in occlusion” manner but as an alternative periapical film can be used for separate views of the maxillary and mandibular teeth, using a horizontal bitewing angulation).

2. 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 a periapical film.

3. Edentulous Areas

Periapical radiographs of edentulous arches or areas, especially the third molars, which may be impacted or previously extracted. 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.

4. Extra oral Radiographs

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

5. Disposition of Radiographs

Double pack intra oral film is recommended. One set of films 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. If digital

radiology was utilized, the odontologist should have all the digital files backed up to an external source after electronically submitting the case records.

NOTE: *All duplicate/digital films should bear right and left notations.*

II. COMPARISON OF ANTEMORTEM & POSTMORTEM EVIDENCE

This section deals with factors which may be present in both the antemortem and postmortem dental evidence and can be useful for comparison purposes. Most dental identifications are based on restorations, caries, missing teeth and/or prosthetic devices which may be readily documented in the records. It should be noted, however, that the precipitous decrease in caries incidence in recent years will dictate greater reliance on other dental findings in the future. It is emphasized that, given adequate records, a nearly infinite number of objective factors have identification value (see Section IV). Thus, objective findings, particularly those which 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. The following subsections provide examples of objective findings in the teeth, periodontium, and/or jaws, which may be demonstrable in both antemortem and postmortem records. While the factors listed are by no means comprehensive, they may serve as a checklist and demonstrate the range of objective findings that may be applicable in difficult identification cases.

Dental Features Useful in Identification:

Teeth:

Teeth present-erupted

Teeth present-unerupted/impacted

Missing Teeth:

Congenitally missing

Lost antemortem

Lost perimortem/postmortem

Tooth Type:

Permanent mixed dentition

Retained primary teeth

Supernumerary teeth

Tooth Position

Malpositions: facial/lingual version, rotations, supra/infra positions, diastemas, other occlusal discrepancies

Crown Morphology

Size and shape of crowns

Enamel thickness

Location of contact points, cemento-enamel junction

Racial variations: e.g. shovel-shaped incisors, Carabelli cusp, etc.

Crown Pathology

Caries

Attrition/abrasion/erosion

Atypical variations: e.g. peg laterals, fusion/gemination, enamel pearl, multiple cusps

Dens in dente

Dentigerous cyst

Root Morphology

Size, shape, number, dilaceration, divergence of roots

Root Pathology

Root fracture, hypercementosis, external root resorption, root hemisections

Pulp Chamber and Root Canal Morphology

Size, shape, number, secondary dentin

Pulp Chamber and Root Canal Pathology

Pulp stones, dystrophic calcification

Root canal therapy: e.g. gutta percha, silver points, endo paste, nanoparticulates, posts, and retro-fill procedures

Internal resorption, apicoectomy, periapical pathology, periapical abscess/granuloma/cyst, cementoma, condensing osteitis

Dental Restorations

Metallic restorations: amalgams, gold or non-precious metal crowns/inlays, endo-posts, pins, fixed prostheses, implants

Non-metallic restorations: acrylics, silicates, composites, glass ionomers, porcelain, zirconia, etc.

Partial and full removal prostheses

Periodontium

Gingiva: morphology/pathology

Contour: gingival recession, focal/ diffuse enlargements, interproximal craters

Color: inflammatory changes, physiologic or pathologic pigmentations

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

Residual root fragments, metallic fragments

Maxilla and Mandible:

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 and 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.

III. CATEGORIES & TERMINOLOGY FOR BODY IDENTIFICATION

A. Positive Identification

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

B. Possible Identification

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 positively establish dental identification.

C. Insufficient Evidence

The available information is insufficient to form the basis for a conclusion.

D. Exclusion

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

NOTE: The forensic dentist is not ordinarily in a position to verify that the antemortem records are correct as to name, date, etc.; therefore, the report should state that the conclusions are based on records which are purported to represent a particular individual.

(Revised 02/2017)

ABFO Standards and Guidelines for Dental Age Assessment

The use of these standards and guidelines is intended to enhance the quality of forensic dental age assessment and reporting. Use of other age assessment modalities such as anthropologic methodologies should be considered if available. All age assessment methods have advantages and shortcomings, and are dependent upon the availability or existence of suitable population specific reference data.

ADA Technical Report No. 1077 - 2020

AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1077 FOR HUMAN AGE HUMAN AGE ASSESSMENT BY DENTAL ANALYSIS

PREFACE

The assessment of chronologic age for living or deceased individuals requires careful documentation. Procedures to assess human chronologic age have been recommended by numerous forensic organizations, including the American Board of Forensic Odontology (ABFO), American Society of Forensic Odontology (ASFO), and the International Organization for Forensic Odonto-Stomatology (IOFOS) as well as others.

The goal of this technical report is to provide the best available current information and guidance for estimating age from the human dentition. It includes guidelines on how to obtain forensic dental data and the selection of recommended methodologies to establish accurate assessments of human chronologic age. It is intended for practitioners performing dental age assessments and for individuals, groups, or agencies utilizing the age assessment information.

Dental age assessment is highly technical and requires skill, training, education, and experience to execute correctly.

This document provides a guideline to generate an estimated dental age and age interval utilizing databases and scientifically reviewed algorithms. However, dental age assessment is based on large identifiable human group populations and has an associated level of uncertainty. It is beyond the scope of this document to determine the appropriate use of this assessment by any entity in determining appropriate actions based on the estimated *age* interval as it relates to the chronological age of any specific individual. It is beyond the scope of this document to recommend the application of the assessment by any user in determining appropriate actions as it relates to chronological age.

BACKGROUND

Forensic dental age assessment is the estimation of an individual's chronologic age through scientific evaluation of the dentition and maxillofacial structures. Medico-legal applications in the deceased include estimation of the age at death and assist in the identification of missing and unidentified individuals by narrowing search parameters. In the living, it will assist the legal system in answering questions regarding immigration, legal age of majority, and legal age of

license. In the US, only the courts or designated agencies determine legal disposition of the individual. The forensic dental age assessment practitioner reports the facts as best as they are understood and does not get involved with policymaking.

The complexity of the age estimation process requires forensic dental age assessment practitioners to follow these guidelines to the fullest extent applicable, practical, and appropriate to ensure scientific integrity. In addition, the consequences of inappropriate assessment of age can have emotional and legal ramifications. Age assessment methods vary in their advantages and disadvantages and are dependent upon the availability of suitable population-specific reference data. In addition, whenever possible, multiple independent dental and non-dental methodologies should be performed by qualified practitioners.

1 RATIONALE

Forensic dental age assessment produces an estimate of chronologic age through dental analysis. The intent of this technical report is to describe current best practices for the process of human dental age assessment; however, it is not intended to supersede local, state, or federal regulations. As a resource, this document could assist in the development of regulations for those agencies.

2 SCOPE

This document describes the methodologies and best practices for estimating the chronologic age of a living or deceased individual by analysis of the human dentition and associated maxillofacial structures.

Note 1: This document is not an implementation guide; therefore, the practitioner needs to evaluate the proper techniques and applicability for each method.

Note 2: This is not a legal document and is not intended for that purpose.

3 TERMS AND DEFINITIONS

3.1

Age assessment Database

Information that can be processed to generate normal distribution data or percentile data and assembled to create a reference data set.

3.2

Adolescent Dental Age Interval

The interval in human dental development that begins after all primary teeth are normally shed, and the permanent teeth are developing or developed. The adolescent interval ends when all permanent teeth present are fully developed.

Note: During the adolescent and adult dental age intervals, primary teeth may be atypically retained for various reasons, including congenital absence or ectopic eruption of the permanent teeth that would typically replace them.

3.3

Adult Dental Age Interval

The interval begins when human dental development ends and all permanent teeth have completely formed crowns and roots and continues throughout life.

Note: During the adolescent and adult dental age intervals, primary teeth may be atypically

retained for various reasons, including congenital absence or ectopic eruption of the permanent teeth that would typically replace them.

3.4

Age at Assessment (AaA)

The estimated age and estimated age interval derived from the dental developmental stage or stages present at the time an individual's estimated age is calculated by the forensic dental age assessment practitioner. (For example, the mean age for a subject with observed dental characteristics similar to the individual being evaluated is estimated to be 10.34 years with a minimum and maximum age distribution of 8.67 to 14.33 years on the day of assessment).

3.5

Bias

The variance of measured results as influenced by human perceptions or systemic factors.

Note: It is beyond the scope of this document to outline the numerous types of biases.

3.6

Biologic Age

The age corresponding with the developmental, degenerative, biochemical or isotopic status of an individual.

Note: The rate at which organ systems age may differ from the individual's chronologic age.

3.7

Blinding

The process of withholding information that may *bias* the forensic dental age assessment practitioner.

3.8

Chronologic Age

The difference between the individual's date of birth and a specific later date.

Note: Chronologic age may be expressed in varying degrees of precision and can be derived from computer programs that report age values using multiple significant digits. To correctly interpret and report results, consultation with a statistician may be necessary.

3.9

Dental age assessment

The processes used to produce an estimation of an individual's biologic *age* using dental data and subsequently correlate biologic age to chronologic age.

3.10

Dental Emergence (Eruption)

The process of tooth migration from its initial position in its bony crypt through the gingival tissue and into the occlusal plane.

3.11

Dental Age Estimation

The estimated mean age and the corresponding distribution of ages that result from dental age assessment.

3.12

Dental Age Estimation Technique

A method used for age assessment.

3.13

Dental Data

Dental age assessment involves analysis of available dental data of an individual in her/his current state. The term ‘prior data’ refers to data collected when that individual was in a previously known and documented circumstance and does not mean a specific point in time. The term ‘current data’ refers to the available data for the individual or remains in her/his current state. For a deceased individual requiring age assessment, the current data is referred to as postmortem data. For a living individual requiring age assessment, the data is simply referred to as prior dental data and current dental data.

3.14

Developmental Stages of Dental Growth

Intervals in the morphologic appearance of teeth as the crown or root mature.

3.15

Estimated Age Interval

The estimated age interval expresses the mathematically determined minimum and maximum associated age range at a particular level of uncertainty.

3.16

Expression of Uncertainty (EoU): The parameter, associated with the assessment method used, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

3.17

Forensic Dental age Assessment Practitioner

An individual who provides an assessment of an individual’s dental age based upon accepted methodology.

Note: The term “practitioner” will be used instead of “Forensic Dental age assessment Practitioner” throughout this document as an abbreviated way to describe an individual who provides an assessment of an individual’s dental age based upon accepted methodology.

3.18

Gingival Dental Emergence

The interval in the migration process from a tooth’s initial appearance through the gingival soft tissue to the point of final eruption.

3.19

Identifiable Human Group

A population of individuals based on ancestry or population specificity that reflects a similar genetic, geographic, and environmental background.

3.20

Independent Verification

The process of obtaining a second analysis from a forensic dental age assessment practitioner, blinded to the results of the first practitioner's assessment.

3.21

Infant/Child Dental Age Interval

The interval in human dental development that begins at birth, includes the presence of the developing, developed and resorbing primary dentition as well as the initial development of the permanent dentition. This interval includes the early period of mixed primary and permanent dentitions and ends when the last primary tooth is exfoliated normally.

Note 1 to entry: During the adolescent age and adult dental age intervals, primary teeth may be atypically retained for various reasons, including congenital absence or ectopic eruption of the permanent teeth that would typically replace them.

3.22

Level of Uncertainty (LoU)

This characterizes the dispersion of values used for measuring dental age assessment based on the variation within the data.

3.23

Measurand

A physical quantity or property which is measured.

3.24

Prenatal Dental Age Interval

The interval in human development that occurs prior to birth.

3.25

Reference Data Set (RDS)

The assembly of data related to a specific identifiable human group comprising all the relevant information to enable dental age assessment.

3.26

Reference Study

A detailed investigation and analysis of a specific population to relate chronologic age to dental development and maturation.

4 SCIENTIFIC METHODS OF DENTAL AGE ASSESSMENT

The scientific evaluation of dental and maxillofacial structures for assessment of age can be divided into four criteria:

1. Gross formation and developmental growth changes: The progressive morphologic development of the crown, root, and apex of any given tooth or its timed emergence/eruption sequence. In addition, emergence occurs through alveolar bone or gingival tissue. These changes are discernible radiographically showing progressive mineralization of the crown and roots of each tooth in the human dentition.
2. Maturation and post-formation changes: These are changes following complete morphologic development of the tooth crown and root.
3. Histologic changes: Microscopic changes that include but are not limited to secondary dentin apposition, cementum apposition, root transparency, periodontal attachment, root resorption, and attrition.
4. Biochemical changes: Changes over time in the biochemical nature of teeth that can be measured by laboratory techniques, including but not limited to amino acid racemization, carbon-14 dating, and rare isotope analysis.

The specific circumstances of each individual case will determine the dental age assessment method(s) to be employed. Forensic dental age assessment methods for estimating age are dependent upon the specified developmental growth interval of the individual and the availability of specific teeth for the precise technique.

4.1 Data utilization: Data utilized in dental age assessment is based on reference data sets from sex and population-specific studies. Other factors that may or may not affect dental development, post-formatational dental changes, histologic, and biochemical changes are typically not included. The relative contributions of genetic, environmental, and other factors, when examining variability within and between populations has not been established.

The practitioner provides the best and most accurate assessment of an age interval and is responsible for being familiar with and utilizing current age assessment scientific methodology. Thoughtful consideration should be given to sex, identifiable human group, geographic population specificity, and environmental factors.

4.2 Limits to Scientific Dental Age Assessment Methods: The precise rates at which the processes of developmental, maturational, and post-developmental dental changes occur are unique to each individual. Consequently, age assessment procedures estimate biological age intervals of an individual, from which a chronologic age interval is derived. Biologic age does not necessarily correspond with chronologic age. These procedures generally involve comparison of the individual being evaluated with one or more reference data sets that are described statistically in terms of an average, minimum, and maximum age at which developmental or post-developmental changes occur. The individual being evaluated may or may not progress through these changes at a rate comparable to the subjects in the reference study, thereby giving an over or underestimation of chronologic age. A point estimate of age alone is not an accurate way to describe a dental age estimation. It is unacceptable because it may lead an

investigator to misinformed conclusions about the value of the estimation.

It is advised that reference population studies be utilized, when available, for dental age assessment of an individual to address these limitations. This will increase the probability that the individual is compared to a human reference sample representative of genetic and environmental factors associated with their developmental, maturational, and post-developmental dental changes. In cases where there is not a reference population study comparable to the individual being assessed for age, then the reference population study that most closely aligns with the individual being assessed should be utilized, and direction of possible error reported. The basis for the choice of the reference population should be fully described.

4.3 Ancestry: Analogous to a genetic description of the individual, ancestry refers to a genetic line of descent of an individual, an association with an identifiable human group. Reference population studies used in dental age assessment techniques should recognize identifiable human groups and their respective phenotypic characteristics that may affect age estimation. Comparison of an individual within the same identifiable human group is a comparison of an individual that would more likely possess similar dental formation and developmental growth changes, maturational and post-formation changes, histologic changes, or biochemical changes.

Scientifically, both maternal and paternal sides of descent are considered. Practitioners should maintain awareness that self-reported identifiable human groups may be a sensitive, multidimensional concept influencing the reporting of one line of descent over others that may or may not represent the outcome of genetic testing.

4.4 Geographic Population Specificity: This is the specific location in the world that a population resides, and the ethnic, cultural, environmental, and socioeconomic conditions experienced by that population. Variation in dental development, maturation, and post-developmental change have been observed among populations within the same country or region.

4.5 Sex: Some differences in tooth development and maturational and post-developmental changes between sexes have been documented. In cases where the definitive assignment of sex cannot be determined, a method that does not require a designation of sex should be used, or the assessment using both sexes should be reported.

4.6 Nutritional Health: Consistency of diet may account for gross anatomical changes to teeth such as attrition and secondary dentin formation. These processes will affect the final dental age assessment in some techniques. The rate and extent of development of somatic and non-dental skeletal structures are more readily affected by nutritional status than the dentition in children and adolescents. However, extreme environmental factors may affect the developing teeth. It is prudent that the practitioner is aware of this limitation when assessing the age of an individual who is exposed to such conditions.

4.7 Current and Prior Systemic Diseases: The rate and extent of tooth and skeletal formation can be affected by systemic conditions such as endocrine disorders, especially in the developing individual. Moreover, cancer treatments such as chemotherapy, or radiation therapy applied to developing anatomic regions, may interrupt tooth formation, affecting tooth

morphology. In adults who have completed dental formation, the effects of systemic diseases may also influence maturational and post-formation dental changes.

4.8 Socioeconomic Status: This represents external factors where an individual may or may not have the financial ability or access to adequate health care, dental care, and good nutrition. An individual who is deficient in any of these areas can have delayed development or accelerated deterioration of their teeth and skeleton, which may affect dental age assessment.

4.9 Habits and Addictions that may Affect Health or the Maxillofacial Structures: The following may have unintended consequences to the dentition because of the habits or addictions of the individual: staining, extensive caries, extensive restorations, bruxism, wear, traumatic occlusion, periodontitis, pulpal and periapical disease, tooth loss, and tooth fracture. Specifically, alcohol and drug addictions, drinking dark-colored liquids, tobacco usage and betel nut chewing, poor oral hygiene, and excessive carbohydrate intake are several habits that may adversely alter the teeth and affect dental age assessment. The significance of each condition may vary with the age assessment methodology.

4.10 Additional environmental factors that may affect developmental or post-formation dental and skeletal development include growth hormone therapy, endocrine or immunosuppressive therapies, traumatic injuries, conditions that affect physical development, and postmortem changes.

5 TOOTH DEVELOPMENT AND DENTAL AGE ASSESSMENT

Humans who survive to adulthood normally develop two distinctive sets of teeth: Twenty (20) deciduous teeth with four incisors, two canines, and four molars in both the upper (maxillary) and lower (mandibular) jaws; and thirty-two (32) permanent teeth with four incisors, two canines, four premolars, and six molars in each upper and lower jaw.

Tooth development, the formation and mineralization of the dental tissues (enamel, dentin, and cementum), begins at the most occlusal or incisal portion of each tooth and continues until each root tip is fully formed. Simultaneous with tooth formation is the movement of the forming teeth through the alveolar bone toward the surface of that bone and the overlying gingival tissues. This movement is the process of emergence of the forming teeth first through the bone, then through the gingiva, and normally continuing to the level of occlusion with teeth in the opposing jaw.

Dental development begins before birth and development and emergence can continue for more than twenty (20) years after birth. Visualization of the stages of dental development and emergence of multiple teeth by various imaging techniques facilitate dental age assessment. The assessments result in estimations of the chronologic age of individuals based on comparison to data from a robust collection of peer-reviewed reference studies. Specific techniques should be selected based on case-specific factors, including the general estimated age interval (prenatal, infant/child, adolescent, adult), sex, identifiable human group and whether the individual is living or deceased. In general, techniques based on dental development are more accurate than tooth emergence techniques. Techniques based on gingival emergence, the clinical appearance of the teeth through the gingiva, are the least dependable. Other techniques exist based on post-development changes to teeth for cases in which all teeth are fully developed.

Teeth are well suited for use in the analysis of age assessment. Dental enamel is the hardest

tissue in the human body and teeth can survive many perimortem insults and postmortem conditions. Dental development is less affected by environmental factors, socioeconomic status, nutritional variation, dietary habits, endocrinological, or disease influences than other age assessment methodologies. Relatively simple techniques for assessing age based on dental development are available.

5.1 Tooth Development Stages

This is defined as the various degrees in the development of human teeth that represent specific points of mineralization discernible through a variety of diagnostic imaging modalities.

Tooth development and emergence of human teeth through alveolar bone, as previously mentioned, are more accurate in human dental age assessment than dental emergence through soft tissues. Those tooth development staging systems that use crown/root development or emergence through alveolar bone should be used where indicated over those techniques that are dependent on tooth emergence through soft tissues.

Different dental age assessment techniques use different tooth developmental staging systems. Currently, there is no consensus on what staging system is better. Dental developmental staging systems are method dependent and it is recommended that they be utilized based upon the appropriate reference study.

5.1.1 Assessment of Tooth Stages

When assessing tooth development from dental radiographs or other imaging modality, one can distinguish between consecutive developmental stages more easily using internal hard tissues, such as the shape of the pulp chamber or root canal. This improves sensitivity and performance measures.

5.1.1.1 Crown assessment: The practitioner should assess the thickness and continuity of enamel in the incisal or occlusal surface of any tooth, followed by the presence of dentin and ending with the shape of the roof of the pulp.

5.1.1.2 Root assessment: The practitioner should assess the root as initiated when small divergent spicules appear from the edges of the crown. Thereafter, the amount of root developed should be compared to the size of the crown (lengthwise) until the length of the root exceeds the length of the crown, then attention should be on the root apex in terms of maturity (open, closed and the width of the apical periodontal ligament space).

5.2 Basic Theory of Age Assessment

Most age assessment processes and techniques conform to a specific mathematical probability function called normal distribution. Typical normal distribution can be demonstrated by bell curves that define the extent of the variation for the specific feature(s) the technique investigates. Bell curves can have very similar or very different shapes and are based on the data gathered using the specific method. The bell curves for the different techniques may be similar with a midline peak and symmetry around the midline. They can also appear dissimilar with different height, width, and peak location based on the dispersion of the data and the location of the mean (signified by the peak). Most bell curves demonstrate normal distribution of data; however, the shape may show variations to illustrate the terminal developmental stage.

There are multiple statistical expressions to describe the dispersion of data or level of uncertainty. That statistical expression will be dependent on the specific population reference study used for the dental age assessment.

The use of databases in the evaluation of tooth maturation and post-developmental dental changes is an essential component of dental age assessment. There is still no uniform consensus concerning the appropriate statistical methodology that considers both the age intervals reported in the tables as well as the age interval among the individual teeth utilized in the assessment. Therefore, the reporting of an appropriate standard deviation methodology is beyond the scope of this document.

5.3 Scientific Basis for Dental Age Assessment and Age Interval Calculations

Tooth maturation, which includes developmental and post-developmental changes, as with most biological processes, follows a continuous progression. In addition, the assignment of a predicted time range for a specific stage of maturation is the basis of numerous fields of science and medicine, including embryology, obstetrics, pediatric medicine, and child psychology. The success of key diagnostic and therapeutic decisions based on time intervals listed in published development tables is an established principle of modern medicine.

6 AGE ASSESSMENT DATABASES

6.1 Databases

A dental age assessment database is one or more reference data sets from one or more reference studies. It uses robust, reproducible methods of analysis to estimate the distribution of ages associated with dental development, maturation, and post-developmental dental changes.

The desired attributes of a database include:

1. Adequate sample size: Defined by individual reference studies, or of a combined dataset based on more than one reference study.
2. The provenance of the data: (i.e., The source(s) or identifiable human group from which the data came).
3. Methods and units of measurements clearly defined and described.
4. The ability to assess the impact of varying assumptions or analytic methods on the results.
5. A sufficient level of detail provided in published materials or available from study authors to provide the practitioner with the information needed to address items 1-4 above.

Note 1: Each dental age assessment database uses different metrics and the practitioner shall be responsible for understanding those differences when applying the data to a specific human dental age assessment technique.

Note 2: Dental age assessment database information changes regularly. Current resources for databases can be found in the bibliography section of this document.

6.2 Sexual Dimorphism of Databases

The differences in tempo of development and maturational changes in teeth between males and females are well established. It is recommended that databases reflective of each sex be maintained separately.

Dental age assessment databases need to have distinct sex categories for males and females. Additionally, if sex is not known, then include an unknown category in the database.

6.3 Ancestral Diversity of Databases

The differences in tempo of development and maturational changes in teeth between identifiable human groups are well established. It is recommended that data reflective of a specific identifiable human group be maintained separately.

Dental age assessment databases need to have distinct, identifiable human group categories for ancestry or population specificity. Additionally, if the identifiable human group is not known, it is recommended that an unknown category be added to the database.

6.4 Validation Studies

In dental age assessment, reference datasets and methodologies are created by researchers to develop statistical information for calculating a dental age interval. Testing the reliability of the reference datasets and methodologies to an unrelated population-specific database of a statistically appropriate size and with subjects of a confirmed chronological age can be an important tool for evaluating the dental age assessment process. Dental age assessment research projects should utilize these independent databases and include calibration and testing of the dental age assessment examiners. Once the age interval for each individual is calculated, the test should report how often the chronologic age falls within the assessed age interval. An appropriate accuracy rate for legal purposes is beyond the scope of this document.

7 CONSENT AND PROFESSIONAL CONSIDERATIONS

Forensic dental analysis on living and deceased individuals, including issues of consent, are subject to legal regulations and ethical considerations beyond the scope of this document.

8 COLLECTION OF EVIDENCE

Evidence collection for dental and maxillofacial age assessment techniques should follow the published criteria for the technique(s) selected. Technique selection should be based on criteria specific to the individual case. Evidence can include radiographs, photographs, and teeth or portions of teeth. Teeth or portions of teeth should only be collected as evidence following ethical considerations. It is recommended that the evidence collected be comprehensive and specific to the circumstances of each case. When applicable, the case identification and biographical information data discussed below should also be collected.

8.1 Case Identification Data

To the greatest extent possible and practical, it is recommended that the following case identification data be recorded and archived:

8.1.1 Case Number: A unique alphanumeric identifier. When appropriate, this identifier can be of a type agreed to or designated by the referring agency.

8.1.2 Referring Agency: The agency or authority requesting the analysis. This agency may or may not be responsible for the case investigation or disposition of the case. The referring agency address should also be documented.

8.1.3 Name(s) of the Examiner(s): Full name and pertinent degree(s) of the individual(s) conducting the examination, evidence collection, or analysis of case evidence.

8.1.4 Date of the Examination: Month, day, year, as per the convention of investigating agency.

8.1.5 Setting of Examination: The specific location where the dental age assessment occurred.

8.1.6 Name of Subject: Full or partial name as reported by the subject or by family, witnesses, agencies, or authorities, or provided in documents. It is recommended that known aliases or nicknames be included. If the subject's name is unknown, a suitable unique pseudonym or alphanumeric case number identifier can be used.

8.1.7 Birth Data: Record the date and place of birth claimed or stated by the subject or other information related to the subject's date, and place of birth . Supporting information from family members, witnesses, agencies, authorities, or other documents can be used to reinforce the claimed date and place of birth.

8.1.8 Other Data: Any additional data that may affect the assessment results.

8.2 Biographical Information of the Individual

In addition to the case identification data collected, collect and consider biographical information for each subject.. The biographical data evidence collected should include information that is as comprehensive as possible and practical.

Include in the biographical data available information related to the subject individual's sex, identifiable human group, geographic origin, subsequent places lived, current and former health issues, current and former nutritional status, current and former habits that may relate to skeletal, oral, or dental development or conditions, current and former medications or addictions that may relate to skeletal, oral, or dental development or conditions, and any other environmental or cultural factors that may have affected skeletal, oral, or dental development or contributed to post-development skeletal, oral, or dental changes.

8.3 Dental Evidence Observed, Collected and Measured

The dental evidence observed, collected, and measured is case-specific and may be limited by medical ethics, quality and quantity of dental and maxillofacial remains, best practice techniques available, and permission granted or denied by the medical examiner or pathologist to extract, section or expose dental/maxillofacial structures. Although all dental/maxillofacial structures should be considered, the practitioner needs to list specific teeth or other structures utilized in the assessment of age. It is the responsibility of each practitioner to apply the appropriate scientific methodologies that are consistent with the reference studies' methods and designs.

8.3.1 Dental age assessment Criteria

1. Morphologic developmental tooth staging
2. Dental emergence pattern
3. Any other measured dental developmental or post-formation characteristics
4. Chemical or isotopic analysis

8.3.1.1 Occlusion

This may present as one of several factors contributing to the development of variables utilized in dental age assessment in adults, especially attrition and secondary dentin formation. Factors to consider when evaluating occlusion can include: incisal/occlusal wear, traumatic occlusion, lack of occlusion, enamel quality, diet, function and habits, dental restorations, occlusal adjustments, dental therapy, and dental appliances.

8.3.1.2 Oral Hygiene

Plaque, calculus and debris present risk factors for the development of caries and periodontal disease and are conditions that should be considered in many dental age assessment methods. The practitioner should collect oral hygiene data that may affect dental age assessment outcomes.

8.3.1.3 Pathology

In addition to clinical and radiographic findings of common dental diseases, localized and systemic conditions may affect tooth development or post-developmental changes. Hard and soft tissue lesions of the maxillofacial complex may indicate factors potentially affecting the rate of development or aging. Systemic conditions leading to the absence of teeth and disease processes or therapies affecting morphology or rate of development can preclude dental age assessment.

8.3.1.4 Photographs

A series of extraoral and intraoral clinical or postmortem photographic images are useful in documenting gross clinical or postmortem findings in dental age assessment. Use macro and microscopic photographic techniques when the dental age assessment technique warrants it.

8.3.1.5 Radiographs

Intraoral or extraoral radiographic images consistent with clinical diagnostic views for both living and deceased individuals can be used for most dental age assessment techniques. Standard 2-dimensional radiographic images are typically used in reference studies, although emerging 3-dimensional images show great promise for the future of dental age assessment. Radiographs reveal the current state of morphologic development of dental structures for individuals still undergoing developmental and maturational changes. Also, post-maturational dental changes can be demonstrated and measured in radiographs of teeth and maxillofacial structures. In addition, the detection of dental disease, trauma, and systemic conditions that may affect dental age assessment can often be detected in dental radiographs.

9 DENTAL RADIOLOGY

Dental radiographs are an adjunct to the physical and visual examination of the dental and maxillofacial structures. Depending on the precise context of the issues to be resolved, radiographs provide significant and detailed information enabling accurate age estimation. Radiographs that have been shown to be useful are the dental periapical, panoramic, computed tomography (CT) scans, and cone-beam computed tomography (CBCT). In addition, views comprising lateral, lateral oblique, and anterior-posterior (AP) cranial views may be useful. In both the living and the deceased, dental and maxillofacial radiographs are the source of the most accurate information for age estimation.

Although the primary objective in obtaining radiographs is for age estimation, practitioners are bound by ethical and clinical best practices when assessing subjects. Even though this is a nonmedical or dental referral, the primary responsibility is to ensure that the individual is provided appropriate and accurate information for an individual to give informed consent. In addition, make the subject and those responsible for his or her medical and dental care aware of any clinical issues that are detected during that process.

Obtain the radiographs under review in compliance with all applicable federal, state, and local health requirements and privacy laws.

9.1 Image Acquisition

Practitioners who take radiographic images need to:

1. Establish and maintain operating and safety procedures that ensure radiation exposures are as low as reasonably practicable. This applies to both the subject receiving ionizing radiation and staff who are in the area of the ionizing radiation-emitting device.
2. Provide personal protective equipment (PPE) for the individual being irradiated if appropriate. The best method for minimizing radiation dose for a subject is to limit the irradiated field and reduce the number of exposures.
3. Establish and monitor the designated zone of radiation. This includes correcting breaches of radiation protection protocols. In the unlikely event of overexposure to the subject, immediately refer to a radiation protection physician.
4. Ensure the radiation safety of all persons accompanying the individual, especially when imaging is performed outside a dedicated lead-lined x-ray room. This may occur if handheld imaging equipment is used.
5. Ensure that all images have the correct subject information, identification number, date of birth, date of radiographic exposure, sex, and correct labeling of right or left sides.
6. Be trained in forensics and ionizing radiation methods and competent in the operation of the respective imaging technique.

7. Understand imaging techniques and appropriately explain the reasons for selecting a specific technique to answer the legal question(s) posed, based on knowledge of the capabilities and limitations of the various aspects of imaging.
 8. Be familiar with the most frequently used image processing tools and techniques.
- [1]

10 DENTAL AGE ASSESSMENT METHODS AND TECHNIQUES

Base the age assessment method or technique selection upon the specific circumstances and evidence available for each case (See 4, Scientific Methods of Dental age assessment). When practical, practitioners should utilize multiple independent statistical methodologies. Additionally, the practitioner should utilize and apply the most appropriate statistical data in the assessment of an individual's chronologic age. This includes consideration of the individual's sex, identifiable human group, population specificity, and environmental factors when known. The practitioner needs to precisely follow the methodology of the reference study utilized. This includes but is not limited to the methods for morphologic staging and criteria measurement(s). The use of malformed, diseased, or extensively restored teeth should be avoided when the dental age assessment technique dictates. Staging methods are based on subjective interpretation of observations, and methods have some level of rater variability (inter- and intra-variability). Best practice includes the use of independent assessments of the development stage, with a predefined and documented method for recording each evaluator's results and resolving differences.

Dental age assessment methods/techniques are categorized based upon their applicability to the perceived estimated age interval of each subject and ethical considerations for both living and deceased subjects.

A dental age assessment procedure selection chart can be found in the ABFO *Diplomate's Reference Manual*, Section IV, Standards, and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

An additional resource is published through the European Asylum Support Office, EASO Practical Guide on Age assessment. It is available at: [3] <https://www.easo.europa.eu/sites/default/files/easo-practical-guide-on-age-assesment-v3-2018>

10.1 Atlas

Atlas-based dental age assessment techniques utilize graphic and diagrammatic representations of the morphology of developing tooth structures. Some include the associated emergence patterns. Most, but not all, atlas techniques are non-sex specific and have a limited number of population-specific data sets resulting in a higher degree of variability, particularly in mid-childhood through adolescence. In addition, Atlas techniques are often based on mixed population and ethnic data. Atlas techniques are particularly useful in mass victim identification and clustered victim situations to assist investigators to more efficiently characterize remains by estimated age interval.

A dental age assessment procedure selection chart can be found in the ABFO *Diplomate's Reference Manual*, Section IV, Standards and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

10.1.1 Infant/Child

For the purpose of forensic dental age assessments, the infant/child interval has been defined in the “Terms and Definitions” Section 3 of this document.

Infant/child dental age assessment techniques utilize radiographic evaluation to stage the degree of morphologic development of the primary or secondary dentition as well as resorption of the primary dentition. Infant/child methods/techniques should consider sex, identifiable human group, and population specificity. Therefore, these methods/techniques will generally provide a more accurate and reliable estimate of age over eruption and atlas methodologies. Additional factors that may affect dental age assessment are prenatal conditions and preterm birth. The significance of each condition may vary with the dental age assessment methodology.

The rights of children are enshrined in the United Nations Convention on the Rights of the Child (UNCRC) [4]. This framework underpins all international guidance in relation to children. The 1989 UNCRC is a universally agreed set of non-negotiable standards and obligations that set minimum entitlements and freedoms that should be respected by governments.

Article 37 relates specifically to children who are in conflict with the law and states that they have a right to be treated “*in a manner which takes into account the needs of persons of his or her age*” [4]. Therefore, a credible age assessment is crucial in safeguarding children and juveniles, thus ensuring appropriate treatment. Where the age is not known, the benefit of the doubt should prevail, and he or she is presumed to be a child. The Committee on the Rights of the Child (CRC) recommends that each State party:

...give the benefit of the doubt in age-disputed cases of separated children seeking asylum and seek experts’ guidance on how to determine age. [4,5]

A dental age assessment procedure selection chart can be found in the ABFO *Diplomate’s Reference Manual*, Section IV, Standards and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

10.1.2 Adolescent

For the purpose of forensic dental age assessments, the adolescent interval has been defined in the “Terms and Definitions” Section 3 of this document.

Adolescent dental age assessment techniques utilize radiographic evaluation to stage the degree of dental development toward the latter half of dental morphologic maturation. Although the third molar exhibits the highest degree of morphologic developmental variability, it remains extremely useful in the assessment of age. Utilize early adolescent age assessment methodology when teeth other than the third molar continue to undergo morphologic development. Utilize late adolescent age assessment techniques when the third molar is the only remaining tooth continuing to undergo morphologic development. These techniques play a useful role in assisting legal authorities in determining the disposition of cases involving immigration, asylum seekers, and legal age of majority or license.

A dental age assessment procedure selection chart can be found in the ABFO *Diplomate’s Reference Manual*, Section IV, Standards and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

10.1.3 Adult

For forensic dental age assessments, the adult interval has been defined in the “Terms and Definitions” Section 3 of this document.

Adult dental age assessment techniques may utilize either radiographic morphological evaluation or gross/microscopic observation of post-formation changes within the dentition following the cessation of morphologic dental development. Although others have been described, six traditional post-formation variables have been utilized in the assessment of adult chronologic age. They are:

- 1. Root translucency** – The phenomenon that occurs from the deposition of hydroxyapatite crystals within the dentin tubules over time; it begins at the apex and progresses coronally after the approximate chronologic age 20 years.
- 2. Secondary dentin deposition** – The physiologic or reparative process of laying down additional dentin in the pulp throughout a tooth’s lifecycle.
- 3. Periodontal attachment** – The epithelial and ligamentous attachment between the tooth and the gingival tissues and alveolar bone.
- 4. Cementum apposition** – The continual and usually regular process of depositing new cementum on the root of a tooth throughout its lifecycle; often greater at the apical region than near the cemento-enamel junction.
- 5. Attrition** – The gradual wearing away of the tooth surfaces because of chronic, tooth-to-tooth frictional contact, often due to mastication.
- 6. Root resorption** – Resorption of root cementum and dentin by multinucleated odontoclast activity, often associated with traumatic injuries and prolonged inflammation; it may be internal or external.

Ethical considerations may restrict the use of many adult dental age assessment methodologies due to the requirement of sacrificing tooth structure.

A dental age assessment procedure selection chart can be found in the *ABFO Diplomate’s Reference Manual*, Section IV, Standards and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

10.2 Biochemical

Biochemical dental age assessment techniques require the sampling of dental tissues to evaluate amino acid racemization within the dentin or level of radioactive carbon 14 within the dental enamel. Aspartic acid racemization can estimate the age at tooth extraction or death, while radioactive carbon 14 may estimate the date of birth for individuals born after World War II. These techniques are useful in all age groups and do offer a report of relatively low estimated age intervals. Currently, available biochemical techniques pose ethical considerations for use in the living because of the amount of tooth structure required for testing. The testing methods are complex and laboratory procedures require considerable time to process.

A dental age assessment procedure selection chart can be found in the *ABFO Diplomate’s Reference Manual*, Section IV, Standards and Guidelines. [2] <https://abfo.org/resources/abfo-manual/>

11 REPORTED FINDINGS FOR DENTAL AGE ASSESSMENT

Label the forensic dental age assessment report, “Dental Age Assessment Opinion or Expert Report,” and include the following:

11.1 Introduction

This section provides background information, including:

- Organization requesting report (to include address of individual or organization making request);
- Reason for the request, date of examination, name, and position of practitioner;
- Whether the subject in question was accompanied by a guardian (if so, with name of guardian);
- Documentation of written informed consent and the setting in which the examination was undertaken.

The type of information collected, and the amount of information collected is specific to the circumstances of each case.

11.2 Case Identification Data

This section includes a case identification number and if any age-related legal documents were presented at the date of subject examination, birth certificate, national identification, passport, vaccination certificate, etc.

11.3 Biographical Information regarding the Individual

This section includes the identifiable human group of the individual in question, sex, and the presence or absence of any syndromes or diseases. Also, include a written note regarding the mental and cognitive ability of the individual in question, their general status, and their height and weight.

11.4 Inventory of Evidence

This section lists all evidence received, observed, or collected, including a list of the dentition and anatomic structures analyzed by the practitioner and details the source of the evidence.

11.5 Method(s) of Analysis

This section describes the analytic method(s)/scientific technique(s) and population-specific reference data used in the dental age assessment. A list of anatomic structures analyzed (number and type of teeth analyzed and why specific teeth and structures were used), unit of measurement used, tooth numbering system used, specific technique(s) utilized, and the published reference study where statistical information was obtained should be included in this section of the forensic report.

11.6 Opinion/Conclusions:

This section summarizes the practitioner's results. The final age assessment is a matter of the practitioner's expert judgment by synthesizing all available information. Conclusion statements

specific to each methodology employed includes estimated age, its corresponding level of uncertainty, and an estimated age interval. If a reference study utilized to assess chronologic age does not provide this, then state it in the forensic report. For cases involving immigration, asylum seekers, and legal age of majority or license, include a probability statement that the individual has attained the age in question. When statistical mean age and standard deviation are known, statistical probability can be calculated. The practitioner needs to keep in mind the best interest of the subject undergoing dental age assessment evaluation as the priority.

The report is signed by the practitioner and dated.

11.6.1 Disclaimer

A disclaimer statement indicating that the opinion is subject to review or modification if additional information or evidence becomes available should be added.

12 DATA BACKUPS

Back up digital data on a local computer server and on at least one secure stand-alone backup hard drive; and on secure off-site media or cloud storage. In all cases, follow the appropriate security protocols. Maintain hard copies of material that cannot be readily digitized in a master file and follow security protocols in place for other types of physical evidence for these hard copies as well.

12.1 Cloud Storage of Data

Traditionally, forensic data have 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 these data. When processing and analytical software are included on the same remote server with the forensic data, and delivered over the network, this type of cloud computing is called Software as a Service, or SaaS. Cloud computing has raised issues for the practitioner. These issues are covered in ADA Technical Report No. 1091, *Cloud Computing: Implications and Recommendations for Dental Practice*.

12.2 Data Disposition Guidelines

The practitioner maintains data acquired during a dental examination, records received, written reports and any documented communications in accordance with standard dental/medical protocol.

The examining practitioner may also retain copies of the data in age assessment cases, if security protocols allow, in order to refer to the data should the need arise. However, if security protocols require the ultimate destruction of the data, dispose of the data following approved data destruction protocols. Shred paper documents shredded using crosscut shredding devices. Do not delete electronic media but utilize “wiped clean” specialized software. In addition, encourage physical destruction of electronic media as an additional security measure.

13 DE-IDENTIFICATION OF DATA FOR RESEARCH AND EDUCATIONAL PURPOSES

There are currently no approved guidelines for the proper protocol to anonymize forensic dental data for research and educational purposes. Due to the sensitive nature of this data, exercise extra

care in its use and consultation with the appropriate institutional review committees is strongly advised.

It has been suggested, that at a minimum, to follow federal HIPAA de-identification protocols for the Electronic Health Record prior to using this data. This includes the removal of all 20 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/coveridentities/De-identification/guidance.html>

Remove the following identifiers of the individual or of relatives, employers, or household members of the individual:

1. Names
2. 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:
 - i. The geographic unit formed by combining all ZIP codes with the same three initial digits contains more than 20,000 people; and
 - ii. The initial three digits of a ZIP code for all such geographic units containing 20,000 or fewer people is changed to 000.
3. 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.
4. Telephone numbers.
5. Fax numbers.
6. Email addresses.
7. Social security numbers.
8. Medical record numbers.
9. Health plan beneficiary numbers.
10. Account numbers.
12. Certificate/license numbers.
13. Vehicle identifiers and serial numbers, including license plate numbers.
14. Device identifiers and serial numbers.
15. Web Universal Resource Locators (URLs).
16. Internet Protocol (IP) addresses.
17. Biometric identifiers, including finger and voiceprints.

18. Full-face photographs and any comparable images.
19. Any other unique identifying number, characteristic, or code.

Researchers need to also consider that eliminating all 20 identifiers would still allow for the possibility of re-identification of the individual. In those cases, consider additional aggregation of data to de-identify individuals further.

14 DISPOSITION OF RADIOGRAPHS

Like other forms of digital data, digital radiographs should be backed-up with on-site as well as off-site media or cloud storage media. If photographic (film) media was utilized to image the remains, double pack intraoral film is recommended. Retain one set of films by the practitioner for his/her case file. In identification cases, the second set may be mounted and forwarded with a written report to the referring entities for the master file. As a general guideline, back up digital radiographs in the same manner as other digital media.

15 QUALITY ASSURANCE (QA)

Blinding includes avoiding personal contact with living individuals and obtaining any unnecessary information that can alter the practitioner's perception. It can originate from many sources, including biases, workplace pressures, or even the introduction of external relevant or irrelevant data from the actual investigation.

Independent verification includes an assessment of the use of proper technique, methodology, and conclusions.

16 CONCLUSION

The use of proper methodology and procedure in estimating chronologic age is of utmost importance. Dental age assessment is a common method of estimating age in both the living and the deceased. It is recommended that Forensic dental age assessment practitioners implement these developed guidelines to the fullest extent applicable, practical, and appropriate.

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17 BIBLIOGRAPHY

[1] International Commission on Radiological Protection 2007. The 2007 Recommendations of the ICRP. ICRP Publication 103.

[2] ABFO *Diplomate's Reference Manual*, Section IV, Standards, and Guidelines. Available: <https://abfo.org/resources/abfo-manual/>

[3] European Asylum Support Office Practical Guide on Age Assessment. Available: <https://www.easo.europa.eu/sites/default/files/easo-practical-guide-on-age-assesment-v3-2018.pdf> Included).

[4] United Nations. 1989. Convention for the Rights of the Child [Online]. Available: <http://www.ohchr.org/Documents/ProfessionalInterest/crc.pdf> [Accessed 18/12/2016].

[5] United Nations. 2008. Committee on the Rights of the Child (CRC) [Online]. Available: <http://www2.ohchr.org/english/bodies/crc/docs/AdvanceVersions/C>

18 ADDITIONAL RESOURCES

ADA Technical Report No. 1094, *Quality Assurance for Digital Intra-Oral Radiographic Systems*

ADA Technical Report No. 1091, *Cloud Computing: Implications and Recommendations for Dental Practice*

ISO 1942, *Dentistry – Vocabulary*

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

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, *Standard Practice for Evaluation of Scientific or Technical Data*

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

HIPPA 45 CFR (*Code of Federal Regulations*)

ANSI/ADA Standard No. 1058, *Forensic Dental Data Set*

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