I.O.F.O.S. Recommendations for Quality Assurance: Dental Age Assessment in Living Individuals

Cristiana Palmela Pereira[1], Helen Liversidge[2], Hrvoje Brkić[3], Marin Vodanović[4], Vilma Pinchi[5], Ricardo Henrique Alves da Silva[6], Ashith Acharya[7], Stefano Garatti[8], Sigrid I. Kvaal[9]

[1]President of IOFOS (2023-2026) Faculdade de Medicina Dentária da Universidade de Lisboa, Portugal. Centro de Estatística e Aplicações da Universidade de Lisboa (CEAUL), Portugal. [2]Queen Mary University of London. [3]Treasurer of IOFOS (2023-2026). School of Dental Medicine University of Zagreb, Croatia. [4]Secretary of IOFOS (2023-2026). School of Dental Medicine University of Zagreb, Croatia. [5]Editor JFOS (2023-2026). Sez.dip. Scienze Medico-Forensi - Università di Firenze, Italy. [6]Vice-President IOFOS (2023-2026). Ribeirão Preto School of Dentistry, USP - University of São Paulo. Ribeirão Preto, SP, Brasil. [7]Editor of Newsletter IOFOS (2023-2026). College of Dental Sciences and Hospital Dharwad, India. [8] Webmaster IOFOS (2023-2026). Private Practice Monza, Italy. [9]Dental Faculty , University of Oslo, Norway

Corresponding author:
cpereira@edu.ulisboa.pt

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KEYWORDS

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I.O.F.O.S. Recommendations for Quality Assurance: Bone Age Assessment in Living Individuals - Working Group on Dental Age Assessment in Living Individuals:

Coordinator of the Working Group – Cristiana Palmela Pereira (Portugal)

Working Group Members –Helen Liversidge (England), Sigrid I. Kvaal (Norway).

Drafting Committee Members – Ashith Acharya (India), Hrvoje Brkic (Croatia), Marin Vodanovic (Croatia), Ricardo Henrique Alves da Silva (Brazil), Stefano Garatti (Italy), Vilma Pinchi (Italy).

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ABSTRACT

Age assessment in living individuals is an important question of legal and humanitarian decision-making when reliable identification documents are unavailable.

The *IOFOS Recommendations for Quality Assurance: Dental Age Assessment in Living Individuals* were developed to provide standardized guidance for forensic dental age assessment and have undergone successive revisions over time in response to scientific, methodological, ethical, and legal developments. The most recent revision, completed in January 2026, reflects updated evidence, accumulated practical experience, and evolving international standards.

These recommendations define minimum requirements for case documentation, clinical and radiological examination, method selection, use of population-appropriate reference data, uncertainty estimation, and reporting practices. Particular emphasis is placed on transparency, quality assurance, protection of individual rights, and the legal implications associated with age thresholds, especially the determination of minority or majority.

The revised recommendations are intended to serve as an international reference framework for dental age assessment in living individuals, to be adapted and integrated into national legal and regulatory systems in accordance with jurisdiction-specific requirements.

1. INTRODUCTION

Assessment of chronological age in living individuals is a critical function in many forensic, legal, and humanitarian contexts, especially when reliable birth documentation is absent or disputed.[1-7] In such cases, dental age assessment serves as one of several methods for human age assessment.[2,3,6-13]

As human biology advances through growth and maturation, the dentition offers measurable and broadly consistent markers that, when properly interpreted, help approximate age with forensic relevance.[9,14-21]

Yet this task is inherently problematic: individual variation in developmental timing, genetic and environmental influences, and population heterogeneity all contribute to uncertainty.[17,20-30] Most published methods will only give a mean or median age and use of and interpretation of statistics are crucial in assessing age.[2,29-36] No method yields a perfect point estimate; rather, appropriate method(s) must be acknowledged and quantified.[3,4,29,34,37-42] Therefore, the practice of dental age assessment must prioritize methodological rigor, transparency about error margins, and a cautious interpretive framework.[3,4,7,35,42-48]

In living individuals, additional constraints arise. Ethical and legal aspects demand that imaging, especially involving ionizing radiation, must be justified and minimized.[7,35,46-48,49-53] The dental examiner must balance the need for information with the principle of "do no harm".[49,52] Moreover, in many jurisdictions, age classification holds legal consequences (e.g. minority vs. majority), so the margins of error carry weighty implications.[3,4,6,48-50] Because in some cases the cost of wrongly classifying a minor as an adult is far greater than the converse.[7,49,52] In other cases of disputed age, the question may be if the person old enough. This issue is not confined to the binary determination of child versus adult.[3,4] Age assessment may also be required in other legally and socially relevant contexts, including school grade placement, eligibility for age-grouped sports, estimation of the age of criminal responsibility, and access to social security rights. In certain sporting disciplines, individuals may intentionally misrepresent their age-often claiming to be older than their true chronological age, as reported in sports such as gymnastics.[6,45,48,53-58]

Several independent dental age estimation markers are available (e.g. stages of tooth formation, root development, pulp/tooth ratios, regressive features), each of which can be applied using validated methods.[9,14-17,59-67] Although more than one marker may be assessed in a given case, there is currently no clear evidence that combining different appropriate dental age estimation methods necessarily improves the accuracy of age assessment.[29,33,34,42,45,68] When multiple markers are used, their contribution should be supported by statistical evidence and transparently reported.[3,33,34] Statistical approaches that explicitly quantify uncertainty, rather than relying solely on deterministic staging, enable the expert to report a most probable age together with associated age range and, where appropriate, minimal-age bounds.[2-4,23,33,34,40,41] This document sets forth the IOFOS Recommendations for Quality Assurance in Dental Age Assessment in Living Individuals.[3,4,42,43] Its purpose is to define baseline methodological standards, ethical safeguards, error quantification practices, and interpretive principles so that dental age assessments in living persons are scientifically defensible, transparent in their limitations, and respectful of individual rights. [3,4,43,48,52,69-71]

2. SCOPE

This document presents updated recommendations of IOFOS for Dental Age Assessment in Living Individuals

3. BACKGROUND

- IOFOS recommendations reviewed July 2018 with advice from: Patrick Thevissen (Belgium) – Coordinator of the Working Group; Ashith Acharya (India), Jannick De Tobel (Belgium), Sigrid I. Kvaal (Norway), Sang-Seob Lee (South Korea), Andreas Schmeling (Germany), Tore Solheim (Norway). [74]

- IOFOS recommendations edited (February 2008) with advice from: Guy Willems (Belgium), K.Mesotten (Belgium), K. Gunst (Belgium), Bernard Knell (Switzerland), Anastasia Mitsea (Greece), Ouvehand (Netherlands), Birgitte Sejrsen (Denmark), Sigrid I. Kvaal (Norway). [73]

4. TERMS AND DEFINITIONS FOR DENTAL AGE ASSESSMENT

4.1 Chronological Age

Actual time elapsed since birth.

4.2 Age assessment (Estimated age)

Is the inferred value (or range) of chronological age derived from biological markers and scientific models when the date of birth is unknown or disputed.

4.3 Age classification

Categories reflecting an individual's relative maturity or developmental stage, used for age assessment purposes.

4.4 Age distribution
Statistical concept describing the pattern of ages within a specific developmental stage.
4.5 Age markers
Physiological features that pass through distinguishable stages, each associated with a specific chronological age range.
4.6 Age range (Age interval)
A continuous interval between two defined age limits, within which an individual's true chronological age is estimated to lie.
4.7 Age assessment database
Information processed to generate reference distributions or percentile data for age estimation.
4.8 Bias
Variance of measured results influenced by human perceptions or systemic factors.
4.9 Biological age
Reflects the level of physiological maturity or development of an individual, inferred from biological markers (e.g. dental, skeletal) relative to normative reference data.
4.10 Blinding
Withholding information that may bias the forensic dental age assessment.
4.11 Dental age
Age inferred from tooth development stages or structural dental changes, used to approximate chronological age.
4.12 Dental age range (interval) assessment
Processes using dental information and relating it to chronological age.
4.13 Dental age assessment technique
Method used for dental age assessment.
4.14 Dental data
Analysis of an individual's dental condition in their current or previously documented state.
4.15 Expression of uncertainty
How the uncertainty around an estimated age is communicated (e.g. probability intervals, confidence bounds, or minimum-age statements).
4.16 Legal age threshold
Age defined by law for a person to acquire specific legal rights and responsibilities.
4.17 Range of uncertainty
The maximum and minimum values of the estimate, given measurement error and variability.
4.18 Maximum probable age
Highest probable value inferred from a particular developmental or regressive stage.
4.19 Minimum probable age
Lowest probable value inferred from a particular developmental or regressive stage.
4.20 Most likely age
Value that best corresponds with available scientific and medical indicators.
4.21 Most probable age interval
Value or range with the highest likelihood of representing an individual's true time since birth, based on biological indicators.
4.22 Probability
A numerical measure of the plausibility that a given biological developmental marker corresponds to a specific chronological age, considering the inherent uncertainty of the assessment.
4.23 Reference population
Group of individuals against which an assessment is compared, often having known developmental data.
4.24 Reported age
The age value declared by the individual.

5. DENTAL PROCEDURES AND STEPS

Note:
The procedures and steps described in this document are recommendations. They may be followed provided that:

1. A procedure or step may be used when it is considered suitable for adoption.
2. A procedure or step should only be used if **(a)** it complies with all applicable local legal and ethical requirements and **(b)** it is supported by the best available scientific evidence.

5.1 Dental Examination Methods

5.1.1
Dental clinical examination must include assessment of dentition status which teeth are clinically present, specific characteristics of certain teeth, according to referred scales: the degree of attrition, the occlusion, the colour of the teeth, the staining and calculus, the periodontal condition, the dental hygiene status and any oral pathology.
5.1.2
Any ionizing imaging must follow the ALARA principle (as low as reasonably achievable), with justification and dose minimization.
5.1.3
The dental imaging must be of sufficient quality and resolution to allow reliable staging of dental developmental markers.
5.1.4
The dental method(s) chosen should be compatible with the individual's developmental

stage (for instance, methods of tooth formation for juveniles and subadults; degenerative structural methods for adult individuals).

5.1.5
When possible, dental methods should be used in conjunction with other biological markers.
Note: Evidence supporting multimodal age assessment remains limited, with few validated approaches (e.g., BioAlder). However, emerging methodologies, including DNA methylation, are expected to further support integrated age assessment frameworks in the future.

5.2 Reference Studies and Validation

5.2.1
The reference studies underlying the dental method(s) must meet rigorous criteria: proven ages in the reference sample, adequate sample size, even age distribution, clear definitions of examined features, statistical measures of scatter and reproducibility.

5.2.2
The expert must check that the method's reference population is appropriate (in terms of ethnicity and sex) relative to the examined individual.

5.2.3
The method must have documented reproducibility (inter- and intra-observer) and have been validated in independent samples.

5.3 Dental Examination Procedure in Individual Case

5.3.1
The identity of the individual or the evidence in question should be established or verified and ideally a photograph should be taken. The ethnicity and given chronological age should be registered.

5.3.2
The following information should be obtained from the individual in question or from the evidence and should be reported: (a) Financial circumstances of the family; (b) History of previous food and water supply; (c) Current or prior systemic diseases; (d) Previous dental problems and treatment; and (e) Dental hygiene.
Note: This information is collected as part of the standard anamnesis; however, there is no scientific evidence that it influences dental development or dental age assessment.

5.3.3
Acquire the dental medical images needed ensuring correct technique and optimal image quality.

5.3.4
Confirm which teeth are visible on the images, note restorations, pathology, attrition, and anomalies compared to the clinical examination.

5.3.5
Apply the dental method(s) to assess developmental or structural change.

5.3.6
The method(s) used should be checked against: (a) The number, origin, age and sex distribution of the subjects included in the reference sample used; (b) The reproducibility of the used parameter registration technique; (c) The scientific soundness of the statistics used; (d) Its/their reproducibility; and (e) The validation of its/their outcomes.

5.3.7
Use methods as originally described in peer reviewed literature.

5.3.8
You may combine different methods.

5.3.9
If more than one dental method is used, combine results judiciously, using a transparent procedure (or expert rationale) when literature lacks a standard combining rule.

5.3.10
The report should make reference to each method used. If procedures to combine the methods used (and related parameters) are not properly described in the scientific literature, they should be performed based on the experts experience and the result should be reported with a detailed explanation.

5.4 Reporting and Interpretation

5.4.1
The expert should be able to advise the appropriate instructing authority or appropriate person/s (assignor/s) regarding the limitations of age assessment and what is possible to achieve.

5.4.2
The expert will report (oral and/or written) the age assessment findings to the assigner. The report should include clinical findings on images (radiographic/tomographic).

5.4.3
The report should contain a minimum age and/or an estimated age plus a measure of its

uncertainty, and (an) answer(s) to the request(s) in the age assessment assignment.
5.4.4
The report must state clearly for each applied dental method: the dental method, reference study used, the observed staging, and how that stage translates into an age estimate (or interval) plus uncertainty.
5.4.5
The report must discuss potential sources of error or bias (e.g. deviation from reference population, observer error, dental pathology) and, where possible, quantify their impact.
5.4.6
Differences or inconsistencies between dental and other age markers must be critically examined and explained.
5.4.7
The expert should interpret the dental age estimate in light of the overall case question (e.g. threshold age) and possibly express the probability that the individual is above or below certain age limits.

5.5 Quality Assurance and Review

5.5.1
Each dental age assessment should ideally be performed by two independent examiners. In case of disagreement(s) a consensus between both examiners should be obtained. In case of written report it should be signed by both examiners.
5.5.2
On randomly selected cases and on a yearly basis (at least) previous age assessment investigation(s) should be re-examined, on a blind basis, by the same investigators. In case of disagreement with the first result(s) the procedure used should be checked and adjusted where necessary.
5.5.3
External peer review (blind) of selected cases should be used to assess adherence to protocol and help refine methods when necessary.

6. EXPERT REPORT STRUCTURE

6.1 Front Page

6.1.1
Case number identification
6.1.2
Referring agency
6.1.3
Name of the expert
6.1.4
Name of the person examined
6.1.5
Place of the examination
6.1.6
Date of the examination

6.2 Page 2 Table of Content

6.3 Content

6.3.1 Abstract

The abstract should be composed at the beginning of the report and offer a concise summary of its contents. It must be brief yet precise, covering the essential elements: background, methods, results, and the associated statistical variation. Because many readers may only review the abstract, it must clearly convey the key findings and uncertainties.

6.3.2 Expert declaration

The expert must present their qualifications (a concise curriculum vitae evidencing education, credentials, and relevant experience). They must also state their impartiality and neutrality, clarifying that they hold no familial, professional, or other relationships that might influence their opinion.
By accepting the role, the expert commits to maintaining confidentiality regarding all personal and case-related information obtained in the course of their work. Additionally, they acknowledge a duty to the court or tribunal to provide an objective and unbiased opinion, rather than to advocate for either party.

6.3.3 Assigment

Under the assignment, the expert's report should present the case, lay out the specific questions to be answered, specify the methods to be used, and document informed consent. These elements should all be clearly integrated into the final report.

6.3.4 Background

In the background section, relevant case information should include details that may already be part of the assignment; the subject's country of origin; any declared chronological age; the subject's medical and dental history. Socioeconomic background may also be included, such financial circumstance of the family, history of previous food and water supply.

Note: This information is collected as part of the standard anamnesis; however, there is no scientific evidence that it influences dental development or dental age assessment.

6.3.5 Materials

For materials, the case to be examined must be presented. As part of that, the expert should verify the individual's identity.
Note: In accordance with applicable national regulations and legal frameworks, photographic documentation of the individual may be obtained for identification and documentation purposes.

6.3.6 Methods

In the methods section, it should be specified what has been done, including a clinical oral examination and radiographic examination (such as a panoramic OPG radiograph and other dental X-rays).
In the oral clinical examination, the expert should note teeth clinically present; specific characteristics of certain teeth, colour according to reference scales: the degree of attrition, the occlusion, the staining and calculus, the periodontal condition, the dental hygiene status and any pathology.
In the radiological examination, the report should document teeth present and absent, any pathology (such as caries, impacted/unerupted teeth, retained roots, and any other pathology), and application of the methods chosen.

6.3.7 Results

In the results section, present findings from both oral examination and radiological examination. For the radiological/tomographic component, report the dental grading counting of pixels or results and corresponding dental age assessment according to the chosen reference method. The report may contain a minimum age and/or an estimated age plus a measure of its uncertainty, and (an) answer(s) to the request(s) in the age assessment assignment.
Note: The content and scope of the reported results depend on the specific request made by the competent authorities and on the applicable national legal and procedural regulations. Reporting an estimate of uncertainty is mandatory.

6.3.8 Discussions/Considerations

In discussing the dental results, the expert should address how long carious teeth needed to be present in the mouth for sufficient time for decay to develop, thereby implying a minimal duration of presence and influencing age interpretation. The presence of significant dental caries may skew estimates, and thus its influence on the age assignment must be critically assessed. Missing teeth must also be considered: whether their absence is due to congenital agenesis or earlier removal, as that will affect which developmental markers remain available. Additional factors (e.g. enamel hypoplasia, restorations, periodontal disease) should also be evaluated with respect to their potential to bias or obscure true developmental signals.

6.3.9 Conclusion

The expert should state: "In my opinion, based on the observed dental and imaging findings, the individual's most probable age falls within the range of [X to Y] years, with a minimum age bound of [Z] years. This estimate accounts for statistical variation and uncertainty inherent to the methods applied". The report also addresses the plausibility of any reported age in light of the developmental evidence and recognizes that the "minimum-age concept" prevents overestimation, thus safeguarding against misclassification of minors.

6.3.9.1 Finalise

In the finalisation of the report, local legal conventions should be considered. The document must include the date, the signature of the expert, and, where required, a counter-signature.

6.4 Writing Report

In writing the report, is recommended to paginate all pages and structure the text into paragraphs with clear headlines and sub-headlines. It is also recommended to use short sentences to enhance readability. The language should be accessible to non-specialists; technical terms must be explained, and a glossary of technical words may be included. There is no universally mandated format, as practices may vary across countries. Wherever possible, two experts should be involved in preparing or reviewing the report to strengthen validity.

7. CONCLUSIONS

In dental age assessment, the expert's report should present a most likely age and/or a minimum age bound and critically examine the plausibility of any declared age. When at least one developmental marker has not reached maturity, this indicates ongoing growth and must be considered in the final interpretation. If the most likely age exceeds a legally relevant threshold (such as 18 years), it may be inferred with reasonable probability that the threshold has been crossed, provided the uncertainties and variation in reference data are rigorously assessed. The adoption of the "minimum-age concept" further ensures that the dental age estimate does not overstate the true age, thereby favouring a conservative approach that protects against misclassifying minors as adults.

8. SUMMARY

Forensic age assessments are often requested by judicial or administrative authorities when a person's true age cannot be confirmed. Experts in forensic odontology field have an obligation to carry out these assessments; refusal without valid justification may result in legal consequences. An age assessment report must clearly present the reliability of the methods employed so that decision-makers (judges, agencies) can properly weigh uncertainties and support the legally safer outcome for the individual when doubts remain.

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