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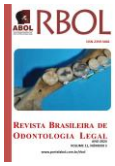

Forensic odontology

DENTAL AGE ESTIMATION QUIZ: TEST YOUR KNOWLEDGE

Quiz em estimativa da idade pelos dentes: teste seu conhecimento.

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ABSTRACT

Forensic odontology plays a vital role in criminal investigations and medico-legal cases, utilizing dental evidence to assist in the identification of individuals and the resolution of legal matters. This paper introduces a comprehensive educational resource that integrates an advanced-level multiple-choice quiz with detailed answers and explanations, aimed at testing and enhancing the knowledge of forensic odontologists and dental professionals. The quiz comprises twenty carefully designed questions that cover various aspects of dental age estimation in children, subadults, and adults. Each question presents a challenging scenario or concept, requiring participants to apply their understanding of forensic dental age estimation principles and techniques. In addition to the quiz, this paper provides thorough answers and explanations for each question, offering valuable insights into the underlying principles, methodologies, and techniques involved in dental age estimation. A section dedicated to research methodology and statistics has also been included, emphasizing its importance for professionals pursuing dental age estimation research. By presenting detailed explanations and rationales, this publication serves as both an educational tool and a reference guide for those seeking to deepen their expertise in forensic odontology. This integrated approach supports continuous education and professional development by clarifying advanced-level topics and concepts while encouraging practitioners to expand their proficiency in this specialized field.

KEYWORDS

Forensic odontology; Quiz; Dental age estimation.

INTRODUCTION

Dental age estimation (DAE) is a crucial aspect of Forensic Odontology (FO) that plays a vital role in both clinical practice and research. This highly specialized task requires a high level of technical expertise, along with extensive training, education, and experience to ensure accurate assessments[1]. Recent study highlighted the availability of numerous postgraduate and training programs in FO around the world. However, despite the growing popularity of

these programs, there is no global consensus or standardized curriculum for FO training[2]. This lack of uniformity makes continuous education after graduation essential to staying current and proficient in the field.

The justification for this paper lies in its potential to bridge the gap between theoretical knowledge and practical application in FO, providing a resource that is both educational and directly applicable to forensic practice. It supports the ongoing professional development of Forensic Odontologists (FOs), helping them remain well-prepared to meet the challenges of this specialized field. By offering a comprehensive and integrated learning experience, this paper aims to make a valuable contribution to the proficiency and expertise of practitioners involved in dental age estimation.

This quiz, the first of its kind, is designed to assess knowledge of DAE, focusing on three key sections: children, juveniles, and adults. It also includes sections on methodology and statistics, as a strong understanding of these areas is essential for mastering the science behind DAE and conducting rigorous research. The quiz evaluates familiarity with the limitations, methodologies, and applications of various well-established DAE techniques, while also reinforcing knowledge of research methodology. It is intended to enhance participants' ability to apply DAE techniques in clinical settings and critically evaluate the limitations and challenges of these methods. Ultimately, this helps in refining existing techniques or developing new methodologies tailored to different populations.

QUIZ

A - Children (< 16 Years)

1) *Which of the following factors was not identified as a potential limitation in the application of the method proposed by Cameriere et al. (2006)[3] for age estimation in children using open apices in teeth?*
   a) *Inter-observer variability in measuring open apices,*
   b) *Variation in tooth development between different ethnic groups,*
   c) *Accuracy of radiographic imaging techniques,*
   d) *Influence of systemic diseases on dental development.*

2) *In the study by Willems et al. (2001)[4], which of the following factors was identified as a key consideration in revisiting Demirjian's technique[5] for dental age estimation in Belgian children?*
   a) *Variation in tooth mineralization patterns across different ethnic groups.*
   b) *Influence of socio-economic status on dental development.*
   c) *Accuracy of digital radiographic techniques compared to conventional radiography.*
   d) *Assessment of additional dental parameters beyond Demirjian's[3] original criteria.*

3) *In the London atlas of human tooth development and eruption by AlQahtani et al. (2010)[6], what distinctive feature differentiated their approach from previous atlases in terms of dental age estimation?*
   a) *Integration of histological sections to supplement visual observations.*

b) *Application of machine learning algorithms for automated age estimation*
c) *Collaboration with forensic odontologists for real-time validation of findings.*
d) *Utilization of longitudinal data to assess individual variations in tooth development.*

4) *In Nolla's (1960) seminal paper on the development of permanent teeth[7], what specific aspect of tooth development did he extensively analyze to establish a standardized method for dental age estimation?*
   a) *Chronological sequence of tooth eruption events.*
   b) *Variations in tooth morphology across different ethnic groups.*
   c) *Correlation between dental calcification stages and chronological age.*
   d) *Progression of root formation stages in permanent teeth.*

5) *In Demirjian, Goldstein, and Tanner's (1973)[5] system of dental age assessment, what specific aspect of dental development was considered as a potential limitation in accurately estimating dental age?*
   a) *Interobserver variability in interpreting dental radiographs.*
   b) *Variations in tooth mineralization patterns among different ethnic groups.*
   c) *Difficulty in assessing dental maturation stages in deciduous teeth.*
   d) *Influence of systemic diseases on the progression of dental calcification.*

B - Subadults (16-22 years)

6) *In 2003, Gunst et al.[8] conducted a study to estimate age based on third molar root development. In the final regression result, Gunst et al. only used a maximum of two third molars, even though the model prediction is based on three to four third molars. This was done to avoid:*
   a) *Multicollinearity*
   b) *Higher Error-Rate*
   c) *Lower R^2*
   d) *Age Mimicry*

7) *When observing a male post-mortem periapical x-ray, a forensic odontologist observed that all third molars already have a closed apex. If the dental age estimation was done using Gunst et al. (2003) model[8], the conclusion that can be drawn from this observation is:*
   a) *Subject estimated dental age is 20.5 ± 1.52 years old*
   b) *Subject estimated dental age can be above 20.5 years old*
   c) *Take the periapical x-ray of the upper or lower canine*
   d) *The subject dental age cannot be estimated.*

8) *The expected outcome of modifying and adding 3-4 more stages to (for example) Demirjian staging method [5] applied in a third molar would likely be:*
   a) *The method will have a better R^2*
   b) *The method needs to be applied in a 3D modality for clarity*
   c) *The method would have a lower observer agreement*
   d) *The additional stage will have no effect for the model performance*

9) *Although several studies have reported the difference in third molar development rates between populations, the study by Mincer et al. (1993)[9] did not yield this outcome due to:*
   a) *Limited data representing the other population*
   b) *Unequal age distribution*
   c) *The experience of the single observer*
   d) *The usage of modified Demirjian staging system for third molars [10]*

10) In their study on third molar observer, Kullman et al. (1996)[11] recommends that the inclusion of several observers in dental age estimation research should be:
    a) Using several staging systems
    b) Contribute to observer calibration and training
    c) Observing only digital radiographs
    d) Using staging system with finer gradings

C - Adults (>22 Years)

11) Which dental age estimation method in adults (> 23 years old) defined six age-related parameters such as attrition, secondary dentine formation, periodontosis, cementum apposition, root resorption, apical translucency and designed a four-point system?
    a) Johanson, 1971[12]
    b) Solheim, 1993[13]
    c) Gustafson, 1950[14]
    d) Dalitz, 1962[15]

12) Dental age estimation methods in adults primarily rely on regressive changes. However, a few of these regressive changes can be observed in radiographs, such as:
    a) Apical translucency, secondary dentine (indirect), and attrition,
    b) Attrition, secondary dentine (indirect), and root resorption,
    c) Cementum annulation, secondary dentine (indirect), and root resorption,
    d) Periodontal recession, apical translucency, and cementum annulation.

13) In recent years, cone-beam computed tomography (CBCT) has been increasingly utilized for dental age estimation, particularly through volumetric measurement. However, this approach is not commonly employed in children and juveniles due to:
    a) The complexity of the method
    b) The time required for measurement
    c) Cost and benefit in ALADAIP principle[16]
    d) The increased complexity of statistical analysis

14) Which of the following statements is true regarding the method proposed by Cameriere, Ferrante, and Cingolani (2004)[17] for estimating adult age using the pulp/tooth area ratio of canine teeth?
    a) This method can only be applied using periapical X-rays in contemporary populations.
    b) This method can be applied using periapical X-rays and panoramic radiographs in both contemporary and archaeological populations.
    c) This method is suitable only for archaeological populations and cannot be applied using radiographic techniques.
    d) This method is applicable with panoramic radiographs only and not with periapical X-rays.

15) What is the primary limitation of using the Kvaal et al. (1995) method[18] for dental age estimation?
    a) It requires extensive training and expertise in radiographic analysis
    b) The method is applicable to specific single-rooted teeth only,
    c) It is not applicable to populations with diverse dental characteristics
    d) It is more time-consuming compared to other age estimation methods

D - Research Methodology and Statistics

16) Most of the research in adult dental age estimation methods that involve measuring a certain variable (such as open apices or volume) adopt an approach of converting these measurements into ratios. This is done due to…

a) *Simplify the measurements and the usage of the model*
b) *Reduce the error-rate in the results*
c) *Reduce the variability in the measurements*
d) *Increase the inter- and intra-observer agreement*

17) *Calibration between observers through inter- and intra-observer reliability tests is essential when conducting research in dental age estimation. If the tested method employs staging methodology (such as Moorrees[19] or Demirjian[5]), the proper statistical process to use in reliability testing is:*
a) *Cohen's Kappa*
b) *Pearson's Correlation Coefficient*
c) *Student's t-test*
d) *Intra-Class Correlation Coefficient*

18) *An evenly dispersed sample in dental age estimation research, per sex and per age group, is essential to avoid:*
a) *Multicollinearity*
b) *Higher Error-Rate result*
c) *Lower R^2*
d) *Age Mimicry*

19) *Optimal dental age estimation research will split their dataset into two parts: training and testing data, where the training data will be used to build the estimation model, and the testing data will be used to evaluate the model built from the training data. The primary reason to use this approach is:*
a) *Prevent overfitting*
b) *Higher observer agreement*
c) *Higher R^2*
d) *Increase the sample size*

20) *A forensic odontologist was consulted to analyze whether a person has reached the legal age of 18 or not based on a panoramic radiograph. The correct statistical methodology in a paper that can be used to answer this request is:*
a) *Linear Regression Model*
b) *Logistic Regression Model*
c) *Dental Development Atlas*
d) *Weighted ANOVA Scoring*

DISCUSSION

Forensic odontology (FO) is a specialized field at the intersection of dentistry and law, playing a pivotal role in legal investigations involving dental evidence, as defined by Keiser-Nielsen as a branch of forensic medicine focused on the analysis and interpretation of dental evidence[20].

A key aspect of FO is DAE, which is crucial in various legal and medical context[21]. In legal terms, an accurate DAE methodology is essential for determining age of criminal responsibility, maturity in unaccompanied migrants, and classifying individuals in competitive sports[22-24]. In situations where reliable legal documents that determine an individual age is unavailable, DAE becomes vital for addressing humanitarian issues such as early marriage, human trafficking, and child labor[25].

Ensuring the reliability of DAE methodologies requires strict quality control, from population sampling to model development. Furthermore, there is an increasing demand for DAE casework, driven by globalization and the rise of undocumented immigrants, highlights the need to validate current or past methodology and assessing error rates across diverse populations. This creates a demand where FO does not only need a deep understanding on which methodology

to use, but also the statistical part to assess the reliability of DAE. As a result, DAE research has expanded significantly, with development of new methods[26,27], validations, and modifications to some popular methodology and being a central focus within FO field[28].

Despite this growing demand, relatively few postgraduate programs in FO exist globally, contributing to an educational gap, particularly in developing countries[2,29]. Many dental practitioners lack formal training in DAE, as these complex techniques are not consistently covered in standard dental curricula. This gap underscores the necessity for specialized educational programs and ongoing professional development to equip practitioners with the requisite skills.

As FO continues to evolve through research and technological advancements, continuous education is critical. Programs like workshops and seminars provide valuable opportunities for professionals to enhance their knowledge of forensic applications. Interactive tools such as quizzes and case-based exercises further enrich these educational experiences by fostering engagement and reinforcing retention[30]. To address this need, we developed an advanced-level multiple-choice quiz focused on DAE. Traditionally associated with trivial pursuits, the term "quiz" has now evolved to represent a formal "test of knowledge," serving as a basic of knowledge to recall, analyse, and if possible, apply their knowledge[31,32].

Undertaking quiz to assess an individual knowledge has been successfully implemented in other medical fields, notably with undergraduate nursing students, resulting in higher engagement[33]. By presenting challenging, case-based questions, quizzes stimulate critical thinking and provide a dynamic assessment tool. The immediate feedback offered by quizzes enables learners to identify and address gaps in their knowledge, encouraging further study and skill refinement[34].

Moreover, interactive platforms such as quizzes and case studies facilitate global knowledge exchange, allowing professionals from different regions to benchmark their expertise against standardized criteria and share best practices. These tools have the potential to foster dialogue on global challenges and contribute to building a cohesive, well-rounded knowledge base in FO. A commitment to continuous learning enhances dental professionals' ability to manage both routine care and complex forensic cases. Embracing a lifelong learning mindset not only benefits individual practitioners but also advances the entire field of dentistry and FO.

CONCLUSION

With this publication, we aim to provide valuable insights into forensic odontology proficiency and the latest advancements in dental age estimation techniques. Your continued interest and engagement in our research are greatly appreciated.

ANSWERS AND EXPLANATION

The answers can be accessed through this link https://doi.org/10.6084/m9.figshare.27266763 or the QR code below:

RESUMO

A Odontologia Forense desempenha um papel vital em investigações criminais e casos médico-legais, utilizando evidências odontológicas para auxiliar na identificação de indivíduos e na resolução de questões legais. Este artigo apresenta um recurso educacional abrangente que integra um questionário de múltipla escolha de nível avançado com respostas e explicações detalhadas, com o objetivo de testar e aprimorar o conhecimento de odontologistas forenses e profissionais odontológicos. O questionário compreende vinte perguntas cuidadosamente elaboradas que abrangem vários aspectos da estimativa da idade dentária em crianças, subadultos e adultos. Cada pergunta apresenta um cenário ou conceito desafiador, exigindo que os participantes apliquem sua compreensão dos princípios e técnicas de estimativa da idade dentária forense. Além do questionário, este artigo fornece respostas e explicações completas para cada questão, oferecendo *insights* valiosos sobre os princípios, metodologias e técnicas subjacentes envolvidos na estimativa da idade dentária. Uma seção dedicada à metodologia de pesquisa e estatística também foi incluída, enfatizando sua importância para profissionais que buscam pesquisas sobre estimativa da idade dentária. Ao apresentar explicações e justificativas detalhadas, esta publicação serve como uma ferramenta educacional e um guia de referência para aqueles que buscam aprofundar sua experiência em odontologia forense. Esta abordagem integrada oferece suporte à educação contínua e ao desenvolvimento profissional, esclarecendo tópicos e conceitos de nível avançado, ao mesmo tempo em que incentiva os profissionais a expandir sua proficiência neste campo especializado.

PALAVRAS-CHAVE

Odontologia legal; Questionário; Estimativa da idade dentária.

REFERENCES

1) America Dental Association. Technical Report No. 1088 Human Identification by Comparative Dental Analysis: Standards Committee on Dental Informatics; 2020.
2) Al Ghazi R, Gardner A, Mossey P, Abualhija D, Mc Gregor S, Mânica S. A scoping review of websites for forensic odontology training programs. The Journal of Forensic Odonto-Stomatology-JFOS. 2024;42(2):87: 102-87. https://doi.org/10.5281/zenodo.13474319.
3) Cameriere R, Ferrante L, Cingolani M. Age estimation in children by measurement of open apices in teeth. Int J Legal Med. 2006;120(1):49-52. https://doi.org/10.1007/s00414-005-0047-9.
4) Willems G. A review of the most commonly used dental age estimation techniques. J Forensic Odontostomatol. 2001;19:9-17. https://pubmed.ncbi.nlm.nih.gov/11494678/
5) Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45(2):211-27. https://pubmed.ncbi.nlm.nih.gov/4714564/.
6) AlQahtani SJ, Hector MP, Liversidge HM. Brief communication: The London atlas of human tooth development and eruption. Am J Phys Anthropol. 2010;142(3):481-90. https://doi.org/10.1002/ajpa.21258.
7) Nolla CM. The development of permanent teeth. J Dent Child. 1960;27:254-66. https://www.dentalage.co.uk/wp-content/uploads/2014/09/nolla_cm_1960_development_perm_teeth.pdf.
8) Gunst K, Mesotten K, Carbonez A, Willems G. Third molar root development in relation to chronological age: a large sample sized retrospective study. Forensic Sci Int. 2003;136(1-3):52-7. https://doi.org/10.1016/s0379-0738(03)00263-9.
9) Mincer HH, Harris EF, Berryman HE. The A.B.F.O. study of third molar development and its use as an estimator of chronological age. J Forensic Sci. 1993;38(2):379-90. https://pubmed.ncbi.nlm.nih.gov/8454998/.
10) Demirjian A, Goldstein H. New systems for dental maturity based on seven and four teeth. Ann Hum Biol. 1976;3(5):411-21. https://doi.org/10.1080/03014467600001671.
11) Kullman L, Tronje G, Teivens A, Lundholm A. Methods of reducing observer variation in age estimation from panoramic radiographs. Dentomaxillofac Radiol. 1996;25(4):173-8. https://doi.org/10.1259/dmfr.25.4.9084269.

12) Johanson G. Age determination in human teeth. Odontol Revy. 1971;22(21):40-126.

13) Solheim T. A new method for dental age estimation in adults. Forensic Sci Int. 1993;59(2):137-47. https://doi.org/10.1016/0379-0738(93)90152-z.

14) Gustafson G. Age determination on teeth. J Am Dent Assoc. 1950;41(1):45-54. https://doi.org/10.14219/jada.archive.1950.0132.

15) Dalitz GD. Age Determination of Adult Human Remains by Teeth Examination. J Forensic Sci Soc. 1962;3(1):11-21. https://doi.org/10.1016/S0015-7368(62)70094-0.

16) Oenning AC, Jacobs R, Salmon B, Dimitra Research Group. ALADAIP, beyond ALARA and towards personalized optimization for paediatric cone beam CT. Int J Paediatr Dent. 2021;n/a(n/a):676-8. https://doi.org/10.1111/ipd.12797.

17) Cameriere R, Ferrante L, Cingolani M. Variations in pulp/tooth area ratio as an indicator of age: a preliminary study. J Forensic Sci. 2004;49(2):1-3. https://pubmed.ncbi.nlm.nih.gov/15027553/.

18) Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. Forensic Sci Int. 1995;74(3):175-85. https://doi.org/10.1016/0379-0738(95)01760-g.

19) Moorrees CF, Fanning EA, Hunt EE, Jr. Age variation of formation stages for ten permanent teeth. J Dent Res. 1963;42(6):1490-502. https://doi.org/10.1177/00220345630420062701.

20) Keiser-Nielsen S. Person identification by means of the teeth: a practical guide: Wright; 1980.

21) Adserias-Garriga J. Age estimation: a multidisciplinary approach. London: Academic Press; 2019.

22) Rudolphi F, Steffens L, Shay D, Smit C, Robinson L, Bernitz H, et al. Insights into dental age estimation: introducing multiple regression data from a Black South African population on modified Gustafson's criteria. Int J Legal Med. 2025; 139(1)143-55. https://doi.org/10.1007/s00414-024-03312-1.

23) Cunha E, Baccino E, Martrille L, Ramsthaler F, Prieto J, Schuliar Y, et al. The problem of aging human remains and living individuals: a review. Forensic Sci Int. 2009;193(1-3):1-13. https://doi.org/10.1016/j.forsciint.2009.09.008.

24) Angelakopoulos N, De Luca S, Palacio LAV, Coccia E, Ferrante L, Pinchi V, et al. Age estimation by measuring open apices in teeth: a new formula for two samples of South African black and white children. Int J Legal Med. 2019;133(5):1529-36. https://doi.org/10.1007/s00414-019-02096-z.

25) Schmeling A, Grundmann C, Fuhrmann A, Kaatsch HJ, Knell B, Ramsthaler F, et al. Criteria for age estimation in living individuals. Int J Legal Med. 2008;122(6):457-60. https://doi.org/10.1007/s00414-008-0254-2.

26) Olze A, Solheim T, Schulz R, Kupfer M, Schmeling A. Evaluation of the radiographic visibility of the root pulp in the lower third molars for the purpose of forensic age estimation in living individuals. Int J Legal Med. 2010;124(3):183-6. https://doi.org/10.1007/s00414-009-0415-y.

27) Merdietio Boedi R, Shepherd S, Oscandar F, Manica S, Franco A. Regressive changes of crown-root morphology and their volumetric segmentation for adult dental age estimation. J Forensic Sci. 2022;67(5):1890-8. https://doi.org/10.1111/1556-4029.15094.

28) Merdietio Boedi R, Mânica S, Franco A. Sixty years of research in dental age estimation: a bibliometric study. Egyptian Journal of Forensic Sciences. 2023;13(1). https://doi.org/10.1186/s41935-023-00360-3.

29) Syed FMS, Shoro S, Manica S. Pakistan's position in the world of forensic odontology and dental records. The Journal of Forensic Odonto-stomatology. 2020;38(2):47. https://pubmed.ncbi.nlm.nih.gov/33174537/.

30) Dengri C, Gill A, Chopra J, Dengri C, Koritala T, Khedr A, et al. A review of the quiz, as a new dimension in medical education. Cureus. 2021. https://doi.org/10.7759/cureus.18854.

31) Bloom BS. Taxonomy of Educational Objectives: Cognitive domain. Ed. by BS Bloom. vol. 2. Affective domain, by DR Krathwohl and others: Longmans; 1956.

32) Murphy DH, Little JL, Bjork EL. The value of using tests in education as tools for learning—not just for assessment. Educ Psychol Rev. 2023;35(3). https://doi.org/10.1007/s10648-023-09808-3.

33) Hughes M, Salamonson Y, Metcalfe L. Student engagement using multiple-attempt 'Weekly Participation Task' quizzes with undergraduate nursing students. Nurse Educ Pract. 2020;46. https://doi.org/10.1016/j.nepr.2020.102803.

34) Wang Z, Gong S-Y, Xu S, Hu X-E. Elaborated feedback and learning: examining cognitive and motivational influences. Computers & Education. 2019;136:130-40. https://doi.org/10.1016/j.compedu.2019.04.003.