# THE APPLICABILITY OF THE NICODEMO, MORAES AND MÉDICI FILHO'S METHOD (1974) FOR AGE ESTIMATION AMONG CHILDREN, ADOLESCENTS AND YOUNG ADULTS: A SYSTEMATIC REVIEW

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**Palavras-chave:** Determinação da Idade Pelos Dentes. Odontologia Forense. Revisão Sistemática.

**RESUMO**

**Objetivo:** Avaliou-se a aplicabilidade da Tabela Cronológica de Mineralização dos dentes permanentes em Brasileiros para estimativa da idade com fins forenses, por meio de uma revisão sistemática. **Método:** A pesquisa foi desenvolvida baseada no protocolo do *Preferred Report of Systematic Reviews and Meta-Analysis* (PRISMA). As buscas foram realizadas nas bases de dados: Web of Science, Pubmed, Scopus, Cochrane, Lilacs e Sigle, sendo a estratégia baseada no acrônimo PICO/PECO (MAIA; ANTONIO, 2012). **Resultados:** Foram recuperados 10.280 registros nas referidas bases, e após a triagem inicial 20 artigos seguiram para leitura na íntegra. Ao final, permaneceram 5 artigos e mais um foi adicionado por *hand searching*, perfazendo 6 artigos. Os estudos apresentaram delineamento seccional, sendo cinco realizados no Brasil e dois no exterior. A avaliação da qualidade metodológica, realizada com o auxilio do QUADAS adaptado por Lopes (2012), indicou que os 6 estudos apresentaram mais de 50% das respostas positivas, sendo que um atendeu a todos os requisitos. Para comparar as idades estimada com a cronológica, 4 dos artigos utilizaram análise de correlação e os demais, estatística descritiva. Os resultados demonstraram discrepâncias entre a idade estimada e a cronológica, fazendo com que a maioria dos autores indicasse o uso parcimonioso do método, procurando utilizar fatores de correção para populações específicas ou a sua associação a outros métodos de estimativa de idade. **Conclusão:** A evidência científica acerca da aplicabilidade do método de Nicodemo, Moraes e Médici Filho (1974) na estimativa de idade com fins forenses é moderada, sobretudo considerando a quantidade dos estudos existentes e a heterogeneidade metodológica entre eles.

**Keywords:** Age Determination by Teeth. Forensic dentistry. Systematic Review.

**ABSTRACT**

**Objective:** It was evaluated the applicability of the Table of Permanent Teeth Mineralization among Brazilians for age estimation with forensic purposes. **Method:** The PRISMA guidelines (*Preferred Report of Systematic Reviews and Meta-Analysis*) were used for study design, and bibliographical searches were performed in the databases: Web of Science, Pubmed, Scopus, Cochrane, LILACS and SIGLE, according to PICO/PECO strategy. **Results:** A total of 10,280 records were retrieved from the databases, of which 20 articles were selected for full-text analysis after preliminary screening. Five articles plus one additional article selected by manual search were included in the final review, totaling six articles. The selected studies presented a cross-sectional design, five of which were developed in Brazil and two abroad. The assessment of methodological quality, performed with the use of QUADAS adapted by Lopes (2012), indicated that all six studies met more than 50% of the quality requirements and one of them met all the requirements. To compare the estimated and actual chronological age, four studies utilized correlation analysis while two employed descriptive statistics. The findings revealed discrepancy between the estimated age and the actual chronological age, which led the majority of authors to advocate a moderate use of the method as well as to indicate the use of correction factors for specific populations and its association with other age estimation methods. **Conclusion:** the existing evidence on the applicability of the Nicodemo, Moraes and Médici Filho's method (1974) for age estimation with forensic purposes is moderate, given the scarcity of studies and methodological heterogeneity between them.

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# INTRODUCTION

Ascertaining an individual's age is critical to define their legal duties. Thus, according to the Brazilian Civil Code, individuals under the age of sixteen are considered legally disabled persons; individuals aged between sixteen and eighteen years are considered relatively disabled, while those over the age of eighteen are held liable for their actions and thus considered legally capable. Criminally, the individual's ages are considered important in cases of sexual violence, criminal liability and reduction of the criminal conviction.[1,2]

An individual's age can be estimated directly, through clinical examination of the dental arches, or indirectly, with the aid of radiographic images. Direct examination is specifically based on the phenomenon of tooth eruption, which can be influenced by several factors, among them: sex, given that girls have an early tooth eruption process due to their differential pre-puberty and puberty development between 8 and 15 years of age; dental arch, considering that lower teeth erupt sooner than upper ones; and food intake, as severe malnutrition causes a delay in tooth eruption. Pathological conditions, including hypo and hyperthyroidism, anodontia and early loss of deciduous teeth, may likewise affect tooth eruption.[1,3,4,5,6] As for indirect dental examination, the most commonly used approach is the dental mineralization staging, as it is less affected by local factors such as dental cavities caused by caries, premature loss of primary teeth or crowding.[7]

The estimation of dental age of living and dead individuals has aroused interest of researchers worldwide. This is because different populations have been shown to have distinct growth patterns from one another, which generates specific problems in terms of ethical and legal issues.[8]

In Brazil, Nicodemo[9] Moraes[10] and Médici Filho[11] investigated the chronology of tooth mineralization by means of the radiographic method. In particular, Nicodemo[9] studied the development of third molars, while Moraes[10] examined permanent incisives and first molars. Lastly, Médici Filho[11] investigated the development of permanent canines, premolars and second molars. Based on that, the Table of the Chronology of Permanent Teeth Mineralization was created for the Brazilian population, which requires the use of panoramic radiographs to determine at which of eight mineralization stages each specific tooth is, so that to estimate an individual's age.[12]

As it is a method proposed in Brazil and widely used in several localities, its applicability to different nationalities depends heavily on factors like ethnicity and environment, which may ultimately influence the methodology proposed and the study outcomes. In order to make the method universal and more practical to the daily routine of reference centers in each country, including Brazil, it is critical to further evaluate its applicability as reported in our study.

In this systematic review, we evaluated the applicability of the Nicodemo, Moraes & Médici Filho's age estimation method[12] among children, adolescents and young adults, with the aim of gathering the existing evidence on the method and subsequently of subsidizing its implementation, or not, into the routine of forensic experts in Brazil and worldwide.

# MATERIAL AND METHODS

This review was registered in the Open Science Framework (https://osf.io) database (DOI 10.17605/OSF.IO/V4Q96). The methodology was developed in accordance with the protocol for reporting systematic reviews proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)[13], as follows: search strategy, screening of studies based on inclusion and exclusion criteria, selection of articles, methodological quality assessment and risk of biases assessment of selected articles, data extraction, and tabulation.

## Search strategy

Papers published up to May 2017, with no restriction related to date or language of publication, were selected based on the PICO/PECO strategy, where P refers to the study population, I/E to the intervention/exposure, C to the control, and O to the outcome(s). Bibliographical searches were carried out in the following databases: Pubmed, Scopus, Cochrane Library, Web of Science, LILACS and System for Information on Gray Literature (SIGLE). The topics were combined by the Boolean operator "AND" and each topic was created by using the "OR" operator; for that, the topics were extracted from the title, summary and keywords used in the indexing database (MeSH terms). The first topic referred to the different ways of mentioning the population's interest in the central question of this systematic review, and included the following keywords: "children", "adolescent", "young adult". The second topic consisted of I / E, that is, the method used for age estimation, in which the following keywords were included: "forensic sciences", "forensic dentistry", "age determination by teeth" and "radiographic, panoramic". The searches in the different databases are listed in Table 1. We also searched the references of selected articles to identify studies that were not retrieved in the initial search. References from selected articles were also checked to search for additional studies that were not retrieved in the initial screening.

***Table 1**: Eletronic database used and search strategy*

| Pubmed | Web of Science | Scopus | Cochrane | Lilacs | Siegle |
|---|---|---|---|---|---|
| ((((((((((((((((((((((((((((((Child[MeSH Terms]) OR Child[Title/Abstract]) OR Children[Title/Abstract]) OR Minors[MeSH Terms]) OR Minors[Title/Abstract]) OR Minor[Title/Abstract]) OR Adolescent[MeSH Terms]) OR Adolescent[Title/Abstract]) OR Adolescents[Title/Abstract]) OR Adolescence[Title/Abstract]) OR Teens[Title/Abstract]) OR Teen[Title/Abstract]) OR Teenagers[Title/Abstract]) OR Teenager[Title/Abstract]) OR Youth[Title/Abstract]) OR Youths[Title/Abstract]) OR Young adult[MeSH Terms]) OR Young adult[Title/Abstract]) OR Adults, Young[Title/Abstract]) OR Adult[MeSH Terms]) OR Adult[Title/Abstract]) OR Adults[Title/Abstract])) AND ((((((((((((((((((((((((((((Forensic Dentistry[MeSH Terms]) OR Forensic Dentistry[Title/Abstract]) OR Dentistry, Forensic[Title/Abstract]) OR Forensic Odontology[Title/Abstract]) OR Age determination by teeth[MeSH Terms]) OR Age determination by teeth[Title/Abstract]) OR Age determination[Title/Abstract]) OR Age estimation[Title/Abstract]) OR Odontogenesis[MeSH Terms]) OR Odontogenesis[Title/Abstract]) OR Tooth Calcification[MeSH Terms]) OR Tooth Calcification[Title/Abstract]) OR Calcification, Teeth[Title/Abstract]) OR Calcifications, Teeth[Title/Abstract]) OR Teeth Calcifications[Title/Abstract]) OR Calcification, Tooth[Title/Abstract]) OR Calcifications, Tooth[Title/Abstract]) OR Tooth Calcifications[Title/Abstract])))))))) AND ((((Age determination by teeth[MeSH Terms]) OR Age determination by teeth[Title/Abstract]) OR Age determination[Title/Abstract]) OR Ag estimation[Title/Abstract])) | TS=(Child* OR Minor* OR Adolescen* OR Teen* OR Youth* OR "Young Adult*" OR Adult OR Adults) AND TS=("Forensic Dentistry" OR "Forensic Odontology" OR "Age determination by teeth" OR "Age determination" OR "Age estimation" OR Odontogenesis OR "Tooth Calcification" OR "Teeth Calcification" OR "Tooth Calcifications" OR "Teeth Calcifications") AND TS=("Age determination by teeth" OR "Age determination" OR "Age estimation") | (TITLE-ABS-KEY (child) OR TITLE-ABS-KEY (children ) OR TITLE-ABS-KEY ( minors ) OR TITLE-ABS-KEY ( minor ) OR TITLE-ABS-KEY ( adolescent ) OR TITLE-ABS-KEY ( adolescents ) OR TITLE-ABS-KEY ( adolescence ) OR TITLE-ABS-KEY ( teens ) OR TITLE-ABS-KEY ( teen ) OR TITLE-ABS-KEY ( teenagers ) OR TITLE-ABS-KEY ( teenager ) OR TITLE-ABS-KEY ( youth ) OR TITLE-ABS-KEY ( youths ) OR TITLE-ABS-KEY ( "Young Adult" ) OR TITLE-ABS-KEY ( adult ) OR TITLE-ABS-KEY ( adults ) ) AND ( TITLE-ABS-KEY ( "Forensic Dentistry" ) OR TITLE-ABS-KEY ( "Forensic Odontology" ) OR TITLE-ABS-KEY ( "Age determination by teeth" ) OR TITLE-ABS-KEY ( "Age determination" ) OR TITLE-ABS-KEY ( "Age estimation" ) OR TITLE-ABS-KEY ( odontogenesis ) OR TITLE-ABS-KEY ( "Tooth Calcification" ) OR TITLE-ABS-KEY ( "Teeth Calcification" ) OR TITLE-ABS-KEY ( "Tooth Calcifications" ) OR TITLE-ABS-KEY ( "Teeth Calcifications" ) ) AND ( TITLE-ABS-KEY ( "Age determination by teeth" ) OR TITLE-ABS-KEY ( "Age determination" ) OR TITLE-ABS-KEY ( "Age estimation" ) ) ) | #1 MeSH descriptor: [Child] explode all trees<br>#2 Child*<br>#3 #1 or #2<br>#4 MeSH descriptor: [Minors] explode all trees<br>#5 Minor<br>#6 #4 or #5<br>#7 #3 or #6<br>#8 MeSH descriptor: [Adolescent] explode all trees<br>#9 Adolesc* or Teen* or Youth*<br>#10 #8 or #9<br>#11 MeSH descriptor: [Young Adult] explode all trees<br>#12 "Young Adults"<br>#13 #11 or #12<br>#14 MeSH descriptor: [Adult] explode all trees<br>#15 #7 or #10<br>#16 #13 or #14<br>#17 #15 or #16<br>#18 MeSH descriptor: [Forensic Dentistry] explode all trees<br>#19 "Forens* Dentistry" or "Forens* Odontology"<br>#20 #18 or #19<br>#21 MeSH descriptor: [Age Determination by Teeth] explode all trees<br>#22 "Age determination by teeth" or "Age estimat*"<br>#23 #21 or #22<br>#24 MeSH descriptor: [Odontogenesis] explode all trees<br>#25 MeSH descriptor: [Tooth Calcification] explode all trees<br>#26 "Teeth Calcification*"<br>#27 #25 or #26<br>#28 #20 or #23<br>#29 #24 or #27<br>#30 #28 or #29<br>#31 #17 and #30 and #23<br>#32 #17 and #30 | (mh:(Child)) OR (tw:(Child)) OR (tw:(Niño)) OR (tw:(Criança)) OR (tw:(Children)) OR (mh:(Minors)) OR (tw:(Minors)) OR (tw:(Menores)) OR (tw:("Menores de Idade")) OR (tw:(Minor)) OR (mh:(Adolescent)) OR (tw:(Adolescent)) OR (tw:(Adolescente)) OR (tw:(Adolescents)) OR (tw:(Teen)) OR (tw:(Teens)) OR (tw:(Teenagers)) OR (tw:(Teenager)) OR (tw:(Youth)) OR (tw:(Youths)) OR (mh:("Young Adult")) OR (tw:("Young Adult")) OR (tw:("Adulto Joven")) OR (tw:("Adulto Jovem")) OR (mh:(Adult)) OR (tw:(Adult)) OR (tw:(Adults)) OR (tw:(Adulto)) AND (mh:("Forensic Dentistry")) OR (tw:("Forensic Dentistry")) OR (tw:("Odontología Forense")) OR (tw:("Odontologia Legal")) OR (tw:("Dentistry, Forensic")) OR (tw:("Forensic Odontology")) OR (mh:("Age determination by teeth")) OR (tw:("Age determination by teeth")) OR (tw:("Determinación de la Edad por los Dientes")) OR (tw:("Determinação da Idade pelos Dentes")) OR (tw:("Age determination")) OR (tw:("Age estimation")) OR (mh:(Odontogenesis)) OR (tw:(Odontogenesis)) OR (tw:(Odontogénesis)) OR (tw:(Odontogênese)) OR (mh:("Tooth Calcification")) OR (tw:("Tooth Calcification")) OR (tw:("Calcification, Teeth")) OR (tw:("Calcifications, Teeth")) OR (tw:("Calcification, Tooth")) OR (tw:("Calcifications, Tooth")) OR (tw:("Tooth Calcifications")) OR (tw:("Teeth Calcification")) OR (tw:("Teeth Calcifications")) OR (tw:("Calcificación de Dientes")) OR (tw:("Calcificação de Dente")) AND (mh:("Age determination by teeth")) OR (tw:("Age determination by teeth")) OR (tw:("Determinación de la Edad por los Dientes")) OR (tw:("Determinação da Idade pelos Dentes")) OR (tw:("Age determination")) OR (tw:("Age estimation")) | (child OR children OR minors OR minor OR adolescent OR adolescents OR adolescence OR teen OR teens OR teenagers OR teenager OR youth OR youths OR "young adult" OR adult OR adults) AND ("forensic dentistry" OR "forensic odontology" OR "age determination by teeth" OR "age determination" OR "age estimation" OR "odontogenesis" OR "tooth calcification" OR "teeth calcification" OR "tooth calcifications" OR "teeth calcifications") AND ("age determination by teeth" OR "age determination" OR "age estimation") |

**Eligibility criteria**

We included cross-sectional studies with children, adolescents and young adults utilizing panoramic radiographs to estimate their chronological age by the Nicodemo, Moraes and Médici Filho's method.[12] Editorials, literature reviews, case reports, case series and analytical studies that did not compare the effectiveness of the age estimation method, were excluded from analysis. Studies that showed repeated results from the same original publication and those in which the study subjects were from specific populations with a common disease, were also excluded. After initial screening, the selected articles were read in full to confirm their eligibility.

Two examiners, who were responsible for the searches, performed independently the initial selection of articles from the analysis of titles and abstracts. Subsequently, the pre-selected articles were checked in full for their eligibility. In cases of disagreement, consensus was obtained from the discussion with a third examiner.

After full reading of selected articles, thirteen studies addressed the applicability of other methods for age estimation than the method of interest of our study, and one

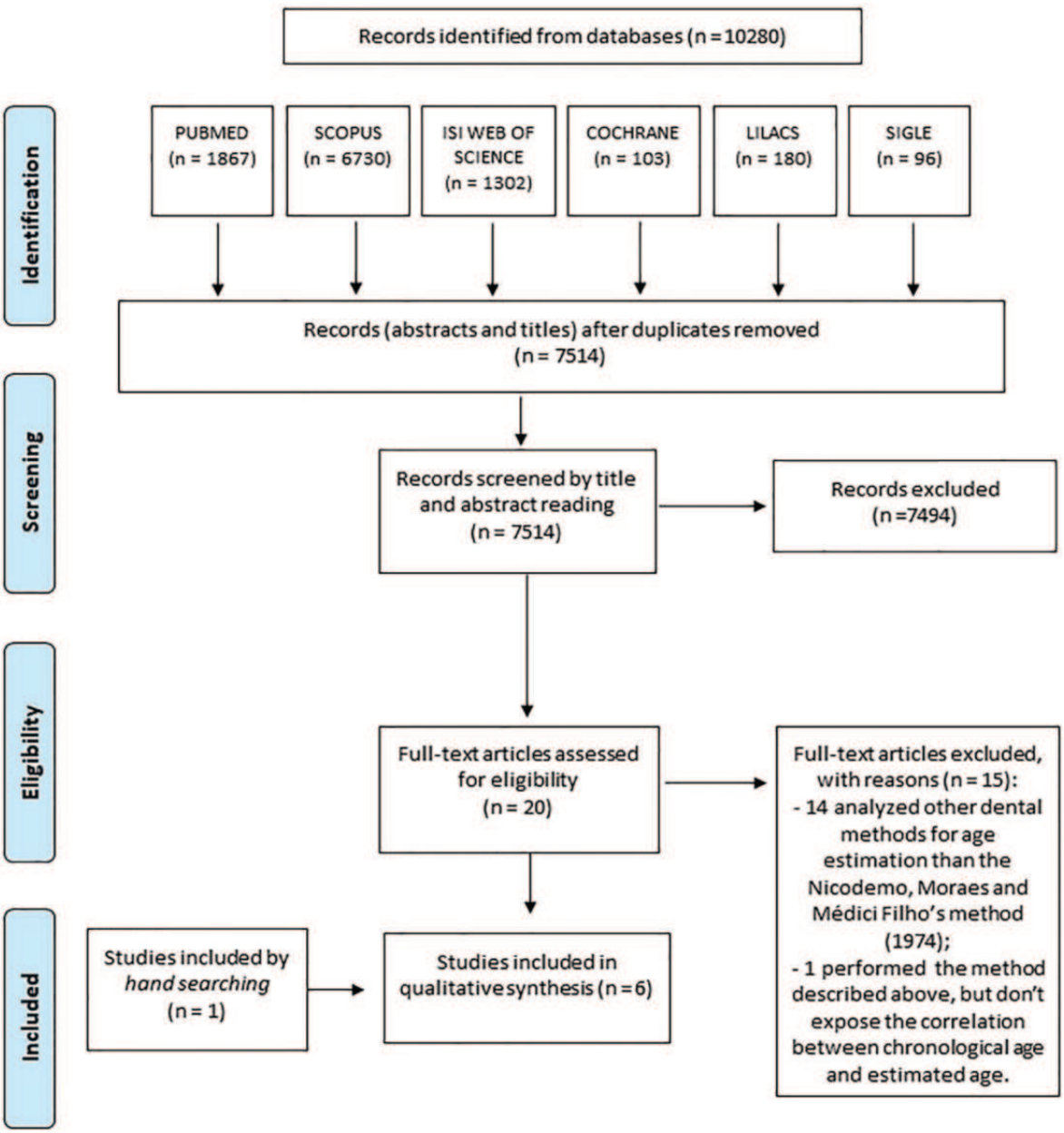


***Figure 1**: PRISMA flow diagram of the search results from the databases.*

used the Table of of Nicodemo, Moraes and Medici Filho for a specific evaluation of third molars. In addition, the latter did not present results regarding the comparison between the estimated and chronological ages. With that, a total of six studies were submitted to methodological quality assessment.

For greater organization in the selection of articles and management of references, the Zotero software version 5.052 was used.

### Quality assessment

The evaluation of the methodological quality and risk of bias of the selected studies was carried out independently by the two examiners using QUADAS 2 (Quality Assessment of Diagnostic Accuracy Studies)[14], which is recommended for studies on the accuracy of diagnostic tests. However, as an age estimation method does not constitute a typical diagnostic test, some adaptations were proposed by Lopes (2012)[15] to fit some questions to the technique.

### Data extraction

A standardized form for data extraction was used, which included, among other information, country or location of study, sample size, chronological age of the study subjects, age estimated by the Nicodemo, Moraes and Medici Filho's method[12] and the approach utilized for data analysis. All steps of this systematic review were carried out independently by two examiners and all possible disagreements were solved through the evaluation of a third examiner.

## RESULTS

A total of 10,280 records were retrieved from the databases, of which 7,516 underwent initial screening (title and abstract) after exclusion of duplicate records. Of these, 7,496 records were excluded from analysis, as they were descriptive studies, editorials, narrative reviews and case reports. The remaining 20 articles were selected for full-text analysis and screened for the eligibility criteria. Of these, 14 articles were excluded due to the following reasons: Thirteen studies investigated the applicability of age estimation methods other than the one of interest; one utilized the Nicodemo, Moraes and Médici Filho's[12] table to specifically assess third molars and did not compare the estimated and the actual chronological ages. During the full-text analysis, one article was included from a manual search through the references of the selected articles. Hence, a total of six articles were included in the systematic review (Fig. 1).

The assessment of methodological quality indicated that all six studies met more than 50% of the quality requirements, as seen in Table II. Only one article (MORENO et al.)[16] met all the requirements listed on the assessment chart. The studies by Rai[17], Oliveira et al.[18] and Miranda et al.[19] only received one "uncertain" score regarding the blinding of examiners to chronological age when the age estimation method was applied. The two remaining articles (KURITA et al.; CARNEIRO et al.)[20,21] did not clearly describe examiner blinding nor the criteria used for sample selection and, therefore, were scored "uncertain" in this regard.

The characteristics of the selected studies are described in Table III. All studies had a cross-sectional design and only two of which were carried out abroad (RAI; MIRANDA et al.).[17,19] The sample size ranged from 43 to 413 individuals, with a minimum age of 70 to 120 months and a maximum of 180 to 300 months. Another variable that differed substantially across studies was the teeth selected for analysis according to the Table of Permanent Teeth Mineralization among Brazilians.[12] Rai[17], Oliveira et al.[18] and Miranda et al.[19] did not mention the teeth analyzed in their studies; another article reported that lower left teeth were analyzed (KURITA et al.)[20]; Carneiro et al.[21] utilized third molars while Moreno et al.[16] proposed two methodologies, one considering 16 teeth and the other analyzing 4 teeth (second and third molars).

Inferential statistical analysis was performed in four of the primary studies, and the authors compared the results between the estimated and the actual chronological age by using correlation tests.

***Table 2**: Assessment of the methodological quality of the studies selected in the systematic review.*

| Quality assessment criteria | Sample with similar demographic and clinical characteristics | Clear selection criteria | Verification of the results obtained | Detailed description of the diagnostic test run | Examiner(s) blinding to the standard reference | Description of the reasons for exclusion of articles |
|---|---|---|---|---|---|---|
| **KURITA et al.[19]** | Yes | Uncertain | Yes | Yes | Uncertain | Yes |
| **RAI.[16]** | Yes | Yes | Yes | Yes | Uncertain | Yes |
| **CARNEIRO et al.[20]** | Yes | Uncertain | Yes | Yes | Uncertain | Yes |
| **OLIVEIRA et al.[17].** | Yes | Yes | Yes | Yes | Uncertain | Yes |
| **MORENO et al.[15]** | Yes | Yes | Yes | Yes | Yes | Yes |
| **MIRANDA et al.[18]** | Yes | Yes | Yes | Yes | Uncertain | Yes |

***Table 3**: Characteristics of the studies included in the systematic review.*

| Author(Year) | Study location | Type of study | Age range | Sample (Males/Females) | Teeth examined | Number of examiners | Statistical analysis | Main outcomes | Conclusions |
|---|---|---|---|---|---|---|---|---|---|
| KURITA, L.M.; NETO, F.H. (2007) | Fortaleza, CE, Brazil | Cross-sectional | 84-180 months | 360 (120/120) | Lower left teeth | 1 | Descriptive statistics (mean, SD, 95% CI) for each age group, Student-Neuman-Keuls test, Pearson's correlation, and linear regression (á=5%). | The estimated age for males was 125.87 (± 29.51) months, with a percentage of variation of 8.0% in relation to the chronological age (135.9 ± 30.4). The estimated age for females was 130.71 (± 29.95) months, with a percentage of variation of 4.0% in relation to the chronological age (135.97 ± 30.83).<br><br>There was no statistically significant difference for both sexes (p-value ⊠0.05). A significant correlation was observed between the estimated and actual ages (0.899 for males and 0.894 for females). A coefficient of determination of 0.8092 was obtained. | Despite the usefulness of the method for age estimation, the use of correction factors (regression equations) is recommended to improve the applicability of the method to the study population. |
| RAI, B. (2008) | New Delhi, India | Cross-sectional | 70-195 months | 413 (207/206) | Not stated | 1 | Descriptive statistics (mean, SD, 95% CI) for each age group, Student's T-test and Pearson's Correlation. | The estimated age for males was 138.4 (± 22.41) months, with a percentage of variation of 3.5% in relation to the chronological age (143.2 ± 1.89).<br>The estimated age for females was 132.49 (± 1.89) months, with a percentage of variation of 3.29% in relation to the chronological age (141.8 ± 3.29).<br><br>There was no statistically significant difference between the estimated and actual ages for both sexes (p-value >0.05). Significant correlation coefficients between the estimated and actual ages were obtained (0.821 for males and 0.923 for females). | While there was a correlation between the estimated and actual ages, correction factors must be utilized to make the method applicable to the Indian population. |

***Table 3**: Characteristics of the studies included in the systematic review.*

| Author(Year) | Study location | Type of study | Age range | Sample (Males/ Females) | Teeth examined | Number of examiners | Statistical analysis | Main outcomes | Conclusions |
|---|---|---|---|---|---|---|---|---|---|
| CARNEIRO et al. (2010 | Maceió, AL, Brazil | Cross-sectional | 108-252 months | 312 (118/194) | Third molars | 3 | Descriptive statistics (mean, SD, 95% CI) for each stage of mineralization; Linear regression graphs and Spearman's correlation were used to evaluate the correlation between the estimated age and the actual chronological age; Student's t-test for difference between sexes. | No statistically significant difference was observed between the sexes, except for stage 7 of upper third molars, which indicated a higher mean age among males.<br><br>The correlation coefficients were 0.853 (upper teeth), 0.867 (lower teeth) and 0.869 (upper and lower teeth), suggesting that the combination of different teeth in the analysis led to a slight increase in the correlation between the estimated and actual ages. | Despite the identification of significant correlations (p-value < 0.01), there were notable differences between the estimated and actual chronological ages. The practical relevance of these differences reinforces the responsibility of forensic dentists during age estimation examination, as the result of which will affect the future of the examinee regarding criminal sanctions. |
| OLIVEIRA et al. (2010) | Cuiabá, MT, Brazil | Cross-sectional | 96-215 months | 200 (100/100) | Not stated | 1 | Descriptive statistics for the percentage of error between males and females and among the total number of analyzed | A total of 54% of age matches (N=108) and 46% of mismatches (N = 92) were observed, with 55% matches and 45% mismatches for males, and 53% and 47% for females, respectively.<br><br>Of the 92 reported mismatches, 43 were related to age overestimation while 49 cases were related to age underestimation. The age matches were more frequent than the mismatches in individuals under 14 years of age. Above this age group, a | The method showed a 54% accuracy when applied in individuals from Cuiabá-MT. The number of mismatches is very significant after the age of 14, so the authors suggest a formula through statistical analysis to ensure greater accuracy of the method in this specific |

***Table 3**: Characteristics of the studies included in the systematic review.*

| Author(Year) | Study location | Type of study | Age range | Sample (Males/ Females) | Teeth examined | Number of examiners | Statistical analysis | Main outcomes | Conclusions |
|---|---|---|---|---|---|---|---|---|---|
| MORENO et al. (2014) | João Pessoa, PB, Brazil | Cross-sectional | 120-300 months | 94 (46/48) | 1st assessment: 16 teeth (8 upper and 8 lower)2nd assessment: 4 teeth (upper and lower second and third molars) | 1 | Descriptive statistics (mean, SD, 95% CI) for each tooth; Pearson's Chi-Square test (á=5%). | The percentage of correctness of age estimation in relation to the chronological age was higher when only 4 teeth (81.9%) were evaluated, as compared to the 16 teeth (4.3%) approach. The highest percentage of correctness was obtained for third molars, both upper (63.8%) and lower (68.1%). No significant difference was observed between the sexes (p-value > 0.05). As for age, the percentage of correctness was significantly higher among individuals aged between 10 and 15 years (94.4%) than among those older than 15 years (65.0%) (p-value □0.001). | The use of the 16-teeth approach was shown to have a low percentage of correctness, while the 4-teeth approach showed more satisfactory results, in particular for individuals aged between 10 and 15 years. Nevertheless, the results regarding age estimation showed a very wide age range, which makes it unfeasible to apply this method solely in the study sample. method solely in the study sample. |
| MIRANDA et al. (2015) | Coimbra, Portugal | Cross-sectional | 72-132 months | 43 (24/19) | Not stated | 4 | Descriptive statistics (simple and relative frequency, mean and SD) for the age ranges | There was a prevalence of 55.85% of males against 44.2% of females in the study sample. Among the age groups analyzed is 72-132 months group, with a mean of 104.11 months (± 18.8). The age was properly estimated as compared to the chronological age in 75% and 68.4% of the male and female population, respectively. Overall, the method had a 71% percentage of correctness (94.5% for 96-108 months, 50% for 120-132 months, and 63.7% for 72-84 | There was a relationship between the chronological age and the development stage in the majority of the sample. The assessment of this method in the study population did not suffice, as different behaviors and patterns were found according to the peculiarities of the samples in each region. |

## DISCUSSION

In this systematic review, we followed the criteria proposed by Lopes[15] for the assessment of methodological quality, which considers the inclusion of studies that meet, at least, more than 50% of the quality requirements. Four out of the six selected articles were performed with a Brazilian population and only two of them included populations from other countries, India and Portugal. These characteristics were expected, as studies addressing the applicability of diagnostic tests commonly present a cross-sectional design. Particularly, it is understandable that most of them were carried out in Brazil, since the method was based on a Brazilian population from São Paulo State and the authors suggested that other regions of the country should also be examined.[12]

In the majority of studies, the applicability of the age estimation method was performed by a single calibrated examiner. Three examiners were included in the study by Carneiro et al.[21] as compared to four in the study by Miranda et al.,[19] whom were tested for their inter-examiner agreement.

Pearson's correlation test was used in the studies by Rai[17] and Kurita et al.[20] to compare the estimated and actual chronological age, while Spearman's correlation was utilized by Carneiro et al.[21] Moreno et al.[16] proposed the evaluation of the hit rate (percentage of correctness) as a means of comparing the estimated age with the actual chronological age. Chi-Square test was employed to verify the difference between the two proposed methodologies, that is, the 16-teeth and 4-teeth assessment model. Such inconsistencies among the selected studies led us not to make a quantitative synthesis as one of the requisites for meta-analysis is the assessment of heterogeneity of primary studies.[22]

The findings of the selected studies revealed a discrepancy between the estimated age and the actual chronological age, which led the majority of authors to advocate a moderate use of the method as well as to indicate the use of correction factors for specific populations and its association with other age estimation methods.

The study by Kurita et al.[20] underestimated the dental age in relation to the chronological age by 8% in males and 4% in females, with no statistically significant difference in both sexes. Rai[17] underestimated the dental age by 3.5% in males and 3.29% in females, with no significant difference. Contrarily, the correlation coefficient obtained by the authors was found to be significant, indicating a discrepancy between the estimated and the actual chronological age, which is in line with the conclusion of this systematic review. The authors recommend that one should combine the Nicodemo, Moraes and Médici Filho's method[12] with other methods to justify its practical applicability or even adjust for correction factors in order to make it valid.

In the study by Carneiro et al.,[21] there was overestimation of age in males when upper third molars at mineralization stage 7 were used as a reference based on the Nicodemo, Moraes and Médici Filho's method.[12] These findings agree with those reported by Cornélio Neto[23], who also observed overestimation of age in males, based on the rationale that third molars undergo mineralization earlier in males than in females, around 104-254 months. Contrarily, Nicodemo, Moraes and Médici Filho[12] reported similar age ranges for both sexes based on the mineralization of upper and lower third molars. A significant correlation was found in the study by Carneiro et al.[21], which demonstrates great variation between the estimated and the actual chronological ages. Consistent with that, Kurita et al.[20] also found a strong correlation with significant differences in the estimated and actual age among males. The practical relevance of these differences reinforces the responsibility of forensic dentists during age estimation examination, as the result of which will affect the future of the examinee regarding criminal sanctions.

Moreno et al.[16] observed that when a few teeth (N = 4) are evaluated in the comparison between the estimated and the actual chronological age, the percentage of correctness increases. On the other hand, it is considerably decreased when several teeth are evaluated (N = 16). The authors also proved that in individuals aged between 10 and 15 years, the percentage of correctness was significantly greater (94.4%) than that in individuals older than 15 years (65.05%).

Miranda et al.[19] evaluated the applicability of the Nicodemo, Moraes and Medici Filho's method[12] in a Portuguese population aged 72 to 132 months (N = 43) using panoramic radiographs. Four examiners were chosen to evaluate the radiographs, with a percentage of correctness of 75% for males and 68.4% for females. In terms of specific age ranges, the percentage of correctness (94.5%) found by Miranda et al.[19] was higher for the 96-108 months group, which is consistent with the study by Moreno et al.,[16] who found a 94.4% percentage of correctness for the age group 10-15 years. When analyzing the 120-132 months group, the latter found an equivalent percentage of correctness (50%) and mismatches (50%). Furthermore, there was overestimation of age in the 72-84 months group (8.6%) and underestimation in the 120-132 months group (11.4%). The authors suggest the combination with other methods given that, despite the ease of application, the Nicodemo, Moraes and Medici Filho's method[12] did not suffice to estimate the chronological age of the study population. Wang et al.[24] investigated the accuracy of the Willems' method for age

estimation through a systematic review. They pointed out that due to the large ethnic and regional difference within a country, it is imperative to increase the sample representativeness and size nationwide, thereby improving the assessment of the applicability of age estimation methods.

The applicability of the Nicodemo, Moraes and Médici Filho's method[12] was also investigated by Oliveira et al.[18] using 200 panoramic radiographs (100 from males and 100 from females) in a sample from Cuiabá, MT, Brazil, aged 8-18 years. Overall, the percentage of correctness was found to be 54% (N = 108), being 55% among males and 53% among females. The percentage of correctness was higher in individuals up to 14 years of age, which corroborates with the studies by Moreno et al.[15] and Miranda et al.[18] In addition, the subjects' age was overestimated in 49 (53.26%) of the mismatch cases and underestimated in 43 (46.74%) of them. These findings disagree with those reported by Miranda et al.,[19] as these authors found that the age was overestimated in 25.58% of the cases and underestimated in 74.42% of them. The low percentage of correctness (54%) reported by Oliveira et al.[18] suggests that the method is not applicable to the population of Cuiabá and, therefore, it needs to be adapted for greater accuracy.

Nóbrega et al.[25] carried out a study at the Federal University of Paraíba to determine the easiness and difficulties experienced by 52 undergraduate dental students when using the Nicodemo, Moraes and Médici Filho's method[12]. This age estimation training was part of the activities developed in the Forensic Dentistry course, with the purpose of exploring the functionality and/or importance of this practice for the students' academic training. The authors concluded that such practical activity contributed to the professional training of the students, as the applicability of the method was the most frequently mentioned positive aspect of the course (19%), while the subjectivity of the method (25%) was defined as the greatest difficulty experienced by the students.

The existence of cross-sectional studies evaluating the applicability of the Nicodemo, Moraes and Médici Filho's method[12] is scarce and did not allow for a for a possible meta-analysis. This demonstrates the need for further cross-sectional studies using this method in different populations, including populations from different regions of Brazil, so that the inter-study comparison and evaluation is made possible.

Taken altogether, the Nicodemo, Moraes and Médici Filho's method[11] was shown to present several shortcomings which prevent it from being utilized alone, particularly due to the high variability observed depending on the geographical location of the sample as well as due to execution flaws.

## CONCLUSION

We conclude that the existing evidence on the applicability of the Nicodemo, Moraes and Médici Filho's method (1974) for age estimation with forensic purposes is moderate, given the scarcity of studies and methodological heterogeneity between them.

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