Testing the Olze and Timme Methods for Dental Age Estimation in Radiographs of Brazilian Subadults and Adults

Ispitivanje metoda Olza i Timmea za procjenu dobi zuba na ortopantomogramima brazilkih adolescenteata i odraslih

Abstract

Aim: This study aimed to test the applicability of the methods proposed by Olze et al. (2012) and Timme et al. for dental age estimation in Brazilian subadults and adults. Material and methods: Panoramic radiographs of 503 individuals aged between 20 and 70 years were analyzed. The mean chronological age of males and females of the sample was 29.04 and 29.97 years, receptively. Secondary dentin formation, cementum apposition, periodontal recession, and attrition of teeth #34, #35, #44 and #45 teeth were assessed as parameters to be calculated in the formulae designed by Olze et al. and Timme et al. Results: In males, the mean estimated age by the Olze method was 28.97 ± 2.86 years, while in females it was 27.85 ± 2.70 years. The Timme method estimated mean age for males of 32.54 ± 5.32 years and for females 33.09 ± 5.16 years. Low coefficients of determination (r) for the application of tooth-specific formulae of both methods suggest that estimated and chronological ages were not properly associated. Conclusion: The outcomes of this study indicate that the Olze and Timme methods may be limited for forensic applications in Brazilian subadults and adults. Country-specific statistical adjustments might be useful for improvements in practice.

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Introduction

Dental age estimation of subadults usually relies on crown-root development observed on radiographs (1), computed tomography (2) and magnetic resonance imaging (3). The transition of subadults into adults manifests in human teeth when the third molars progressively reaches complete rhizogenesis. When this process is finished, dental age estimation becomes more challenging because in adults den-
Material and methods

Study design and ethical aspects

An observational study with retrospective sampling was performed with the approval of the Institutional Committee of Ethics in Human Research (protocol: 54456416.3.0000.5418).

Sampling

Sampling was performed by convenience from an existing image database of panoramic radiographs taken for dental treatment purposes. The inclusion criteria were panoramic radiographs from males or females, aged between 15 and 70 years, with at least one premolar visible for analysis. The exclusion criteria consisted of patients with premolars with large cavities, restorations and prosthetic appliances, severe bone loss, use of orthodontic appliances and the presence of periapical lesions.

The images were analyzed by a single examiner who was not aware of the age and sex of the sampled individuals. The analyses were performed in a personal computer by applied Olze's and Timme's method for dental age estimation. In order to test the applicability of the method in a better way, the sample was divided into the panoramic images of subjects aged between 15 and 40 years and those aged between 15 and 70 years. Age information was retrieved within both methods by assessing the stages of secondary dentin formation, periodontal recession, attrition and cementum apposition in the mandibular first and second premolars of the left (#34 and 35, respectively) and right (#44 and 45, respectively) sides. These parameters were classified into four progressive stages from 0 to 3 and incorporated in specific formu-

Materijal i metode

Dizajn studije i etički aspekti

Provedbu studije odobrio je Institutionalni odbor za etiku v istraživanju ljudi (protokol: 54456416.3.0000.5418).

Analiza uzoraka

Analiza uzoraka obavljena je na temelju podataka iz postoječe baze panoramskih radiografskih snimki učinjenih za potrebe stomatološkog liječenja. Kriteriji za uključivanje bili su panoramske rendgenske snimke muškaraca ili žena u dobici između 15 i 70 godina s barem jednim vidljivim premolaram za analizo. Kriteriji za isključivanje bili su pacijenti s pretkutnjacima s velikim kavitetima, restauracijama i protetičkim aparaturama, teškim gubitkom kosti i periapikalnim lezijama, ili ako se koriste ortodontskim aparaturama.

Slike je analizirao jedan ispitivač koji nije znao dob dob in spol analiziranih snimki. Analize so obvljene na osnovom računalu primijenjenog Olzeovom i Timmeovom metodom za procjenu dentalne dobi. Kako bi se to bolje ispitala primjenjivost metode, uzorak je podijeljen na panoramske slike ispitnika v dobici između 15 i 40 godina in onih od 15 do 70 godina. Podatci o dobi dobiveni so unutar obiju metod procejena faza formiranja sekundarnog dentina, parodontna recesija, atricija in apozicije cementa v prvom in drugem pretkutnjaku donjega čeljusti lejevo (br. 34 in 35) in desnvo (br. 44 in 45, režom). Ti so parametri razvrstani v četiri progresivne stupnje od 0 do 3 in učasčeni v specifične formule (10, 11). Splošno, kronološka dob in procijenjena starost zuba iz obiju metod smatrani so varijablama za analizu podataka v ovoj studiji.
lae (10, 11). Sex, chronological age and estimated dental age from both methods were considered variables for data analysis in this study.

Risk of bias
The risk of bias in this study was more strongly associated with intra- and inter-examiner errors. In order to minimize the errors, the main examiner (with nearly 7 years of experience with forensic odontology) was trained and calibrated for the methods. The main examiners repeated the analysis with 15% of the main sample to enable intra-examiner agreement test. A second trained examiner (with nearly 7 years of experience with forensic odontology) was included. This examiner analyzed 15% of the sample, thus enabling an inter-examiner agreement.

Data analysis
Examiner agreement was calculated with Kappa statistics. Intra- and inter-examiner agreement ranged above 0.8 (p<0.05). Descriptive statistics was used to assess the data related to mean chronological and estimated ages (according to the Olze's and Timme's methods). Measures of central tendency and dispersion were used. Linear regression analysis was the approach taken to compare chronological and estimated ages. Statistical significance was set at 5%. Statistical analyses were performed with R software package (The R foundation, Vienna, Austria).

Results
Five-hundred and three panoramic radiographs (n = 1,598 premolars; #34 = 464, #35 = 376, #44 = 413 and #45 = 345) met the eligibility criteria. The sample was divided in age groups of participants aged between 15-40 years (n = 280; 145 females [mean age: 29.97 years] and 135 males [mean age: 29.04 years]) and between 15-70 years (n = 503; 272 females [mean age: 39.86 years] and 231 males [mean age: 37.81 years]). In the group 15-40, the quantity of teeth #34, #35, #44 and #45 was 272, 269, 251 and 243, respectively. In the group 15-70, the same teeth reached n = 464, 376, 413 and 345, respectively.

The mean of ages estimated in males and females by the Olze method were of 28.97 (±2.86) and 27.85 (±2.70) years, respectively. In the age group of 15-40 years, the Olze method reached a percentage of method fitting of 1.5% within the age estimation.

Risk of pristranost
Rizik od pristranosti u ovoj studiji bio je snažnije povezan s pogreškama unutar ispitivača i među njima. Kako bi se pogreške svele na najmanju moguću mjeru, glavni ispitivač (s gotovo 7 godina iskustva u forenzičkoj stomatologiji) educiran je i kalibriran za metode. Glavni ispitivači ponovili su analizu na 15% uzoraka kako bi omogućili test slaganja unutar ispitivača. Uključen je i drugi educirani ispitivač (s gotovo 7 godina iskustva u forenzičkoj odontologiji). On je analizirao 15% uzoraka kako bi se eventualna pogreška smanjila na najmanju moguću mjeru.

Data analysis
Analiza podataka
Analiza pogrešaka među ispitivačima izračunata je Kappa testom. Slaganje unutar i među ispitivačima kretalo se iznad 0,8 (p < 0,05). Deskriptivna statistika korištena je za procjenu podataka koji se odnose na srednju kronološku i procijenjenu dob (prema Olzeovoj i Timmeovoj metodi). Korištene su mjere središnje tendencije i disperzije. Linearna regresijska analiza korištena je za usporedbu kronološke i procijenjene dob. Statistička značajnost postavljena je na 5%. Statističke analize obavljene su u programskom paketu R (The R foundation, Beč, Austrija).

Table 1
Opisni podatci kronološke i procijenjene dobi zuba na temelju Olzeovih i Timmeovih metoda (ukupni uzorak, 15–70 godina)

| Age * | Method * | Mean | SD | Min. | Max. | Median | Q25 | Q75 |
|-------|----------|------|----|------|------|--------|-----|-----|
| Chronological • Kronološka | Olze's | 38.92 | 12.59 | 19.58 | 70 | 36.91 | 28.08 | 48.25 |
| Estimated • Postignuta | Timme’s | 32.55 | 5.74 | 11.31 | 52.07 | 32.41 | 29.08 | 36.10 |

SD=Standard Deviation; Min. =Minimum; Max. =Maximum; Q25=Quartile25; Q75=Quartile75.
process with tooth 35 and using the mean of measurements of premolars. In the age group of 15-70 years, the percentage of method fitting (applicability to the Brazilian population) was better than the age group of 15-40 years. Method fitting using all the teeth (and the mean of all premolar measurements) ranged between 12.1% and 22.7% (Table 2).

During the analysis of the Timme method, in the age group of 15-40 years, the percentage of method fitting changed from 1.4% to 2.8%. In this process, tooth #45 was not correlated with age. In the age group of 15-70 years, the percentage of method fitting changed from 8.8% to 22.8% (Table 3).

**Discussion**

Dental age estimation may be based on developmental (12, 13), morphological (14) and biochemical parameters (15). The choice for each of the parameters depends on each category of the individual under examination. Developmental information can be retrieved from the human teeth.

**Rasprava**

Procjena dentalne dobi zuba može se temeljiti na razvojnim (12, 13), morfološkim (14) i biokemijskim parametrima (15). Izbor za svaki od njih ovisi o svakoj kategoriji pojedinca koji se ispituje. Informacije o razvoju mogu se dobiti iz ljudskih zuba od intrauterina života do rane odrasle dobi (16).
from intrauterine life to the early adulthood (16). In this time frame, deciduous, mixed and permanent dentitions offer valuable age information from stages of crown-root formation (1, 17-20), measurements of open apices (21-23) and even bone or clinical eruption (24). After eruption in the oral cavity, the human teeth undergo progressive (and mostly degenerative) morphological changes, such as attrition. In particular, the morphological information have more important role in the adult group (4-11), in which the teeth have already finished their development. Morphological parameters can be assessed ex vivo, via destructive approach, or by means of radiology and imaging (25, 26). The biochemical parameters may be investigated and used for forensic purposes without restriction of age group. It depends, however, on the availability of advanced devices and facilities. The present study tested the performance of the Olze (10) and Timme (11) radiographic methods based on morphological parameters.

The methods used in this study retrieved radiographic age information from specific teeth, namely premolars. The choice for these teeth is justified based on technical and age-related reasons. The technical reason relies on the fact that premolars are usually less superimposed with bones (i.e. vertebrae) in panoramic radiographs, and because they have a single root with a large and visible pulp chamber and a root canal. The age-related reason relies on previous studies that revealed a possible correlation of these teeth with chronological age (29). Other age estimation techniques may rely on different teeth and parameters (30, 31). In the present study, the correlation coefficient of premolars with chronological age ranged below moderate (between poor and fair) (32).

These outcomes reflected in the mean error rates that were obtained from the comparison between chronological and estimated dental ages using the Olze and Timme methods. The performance of both methods was very similar in age groups 15-40 and 15-70, with error rates of nearly 5.5 years and 11 years, respectively. The rationale behind the increase of error that almost doubled from group 15-40 to group 15-70 may have relied on the increase in the age interval – from 25 age intervals of one year in group 15-40 to 55 age intervals of one year in group 15-70. As the age intervals nearly doubled the size, the error proportionally followed the same tendency. These findings corroborate a recent study with the Olze method in the same population. According to the existing scientific literature (33), the Olze method is able to reach optimal dental ages using the Olze and Timme methods. The performance of both methods was very similar in age groups 15-40 and 15-70, with error rates of nearly 5.5 years and 11 years, respectively. The rationale behind the increase of error that almost doubled from group 15-40 to group 15-70 may have relied on the increase in the age interval – from 25 age intervals of one year in group 15-40 to 55 age intervals of one year in group 15-70. As the age intervals nearly doubled the size, the error proportionally followed the same tendency. These findings corroborate a recent study with the Olze method in the same population. According to the existing scientific literature (33), the Olze method is able to reach optimal error rates in individuals in the young and middle adulthood (up to 41 years), while worse estimates are obtained in latter ages. In practice, these outcomes direct the attention towards the decision-making process for selecting a method based on the target age group of the examined individual. Examples of age groups are children, subadults and adults (in case of the Olze and Timme methods). Each subgroup might be subdivided (i.e. young- or old adulthood) to facilitate the process of making more specific and optimal decisions about the method to be applied.

As age groups influenced on the decision for specific methods, so did the sex. In females the mean error according to the Olze method was 2.25 years below the mean error in males. This finding may have relied on the increase in the age interval – from 25 age intervals of one year in group 15-40 to 55 age intervals of one year in group 15-70. As the age intervals nearly doubled the size, the error proportionally followed the same tendency. These findings corroborate a recent study with the Olze method in the same population. According to the existing scientific literature (33), the Olze method is able to reach optimal error rates in individuals in the young and middle adulthood (up to 41 years), while worse estimates are obtained in latter ages. In practice, these outcomes direct the attention towards the decision-making process for selecting a method based on the target age group of the examined individual. Examples of age groups are children, subadults and adults (in case of the Olze and Timme methods). Each subgroup might be subdivided (i.e. young- or old adulthood) to facilitate the process of making more specific and optimal decisions about the method to be applied.

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ror according to the Timme method. For males, the difference was 1.57 years. Mean errors within method revealed a considerably discrete difference (0.17 years – higher in females) between females analyzed according to the Olze method. The difference increased within the Timme method (0.82 years – higher in females). These findings point out a primary outcome showing that the Olze method had a better performance among the individuals sampled in this study. Furthermore, it confirmed the need for specific formulae designed for females and males since the error rates between them vary. It must be noted, however, that the sampled distribution based on sex was slightly unequal (272 females and 231 males) in this study. Further studies in the field are encouraged to accomplish homogeneously distributed samples. The comparison of methods within different populations is recommended, as well as the development of specific formulae for populations in which the performance of the methods was not optimal.

**Conclusion**

Low coefficients of determination ($r^2$) for the application of tooth-specific formulae of both methods suggest that estimated and chronological ages were not properly associated. The outcomes of this study indicate that the Olze and Timme methods may be limited for forensic applications in Brazilian subadults and adults. Because of sampling decisions, the outcomes of this study must be carefully interpreted because the age estimates were tested in age limits not originally included. The difference increased within the Timme method (0.82 years – higher in females) between females analyzed according to the Olze method. Razlika se povećala unutar Timmeove metode (0.82 godine – više kod žena). Ti nažalost upućuju na primarni ishod koji pokazuje da je Olzeova metoda imala bolji učinak među pojedincima uočenim u ovoj studiji. Nadalje, potvrđila je potrebu za specifičnim formulama za žene i muškarce jer se stope pogađanja između njih razlikuju. No mora se napomenuti da je uzorkovana distribucija na temelju spola bila u ovoj studiji malo nejednaka (272 žene i 231 muškaraca). Potiču se daljnja istraživanja na terenu kako bi se postigli homogeno raspoređeni uzorci. Preporučuje se usporedba metoda unutar različitih populacija i na temelju specifičnih formula za populacije u kojima provedba metoda nije bila optimalna.

**Conflict of interest**

The authors declare that they do not have conflict of interest related to the present study.

**Authors’ contributions:** T. U. D. – Conceptualization, methodology, formal analysis, investigation, writing – original draft; A. F. – Conceptualization, methodology, data curation, writing – original draft; C. E. P., M., A. R. D., R. H. A. S. – Methodology, software, formal analysis, writing – original draft, visualization; B. M. S., I. L. A. R. – Conceptualization, methodology, investigation, data curation, writing – original draft, E. D. J. – Conceptualization, methodology, investigation, data curation, writing – original draft, supervision, project administration.

**Zaključak**

Niski koefficijenti determinacije ($r^2$) za primjenu formula specifičnih za zube u objema metoda sugeriraju da procijenjena dentalna i kronološka dob nisu pravilno povezane. Rezultati u ovoj studiji pokazuju da metode Olzea i Timmea mogu biti ograničene za forenzičku primjenu kod brazilskih adolescenata i odraslih osoba. Zbog odluka o uzorkovanju, rezultati iz ove studije moraju se oprezo tumačiti jer su procvene dobi testirane u dobnim granicama koje izvorno nisu bile uključene u interval metoda.

**Sukob interesa**

Autori nisu bili u sukobu interesa.
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