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Evaluation of chronological age based on third-molar development in the Serbian population

Procena hronološke starosti zasnovana na razvoju trećeg molara u populaciji Srbije

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Abstract

Background/Aim. Persons identification and their age assessment is necessary in vast number of cases and there are different methods used for such purposes. Numerous studies indicate that the third molar development could play a crucial role in identifying an individual`s age. The aim of this study was to determine the possibility for estimating the chronological age based on the third molar development stages in children and young adults in the Serbian population. **Methods.** A total of 570 Serbian patients aged 6–27 years were included in this study. Out of the total number of subjects, there were 248 males with an average age of 12.21 ± 3.91 years, and 332 females with an average age of 12.88 ± 4.06 years. Stages of dental formation were determined on orthopantomograms by comparing with standard Demirjian radiographic appearances. **Results.** Third molars mineralization occured more rapidly in males than in females. Most of the persons with third molar (the stage H development according to the Demirjian method) were older than 18 years. **Conclusion.** Third molar mineralization stages determination on orthopantomograms is useful additional method for determination of chronological age in living individuals. This finding might be important for forensic studies, focusing on the determination of the legally important ages. Variability among different ethnic groups has to be taken into consideration when applying this method. It is necessary to carry out extensive surveys on a larger sample in order to determine the norms for assessing the dental and chronological age of Serbian population.

Key words:
adolescent; age determination by teeth; child; forensic dentistry; molar, third; radiography, dental; serbia.

Apstrakt

Uvod/Cilj. Identifikacija osoba i procena njihove starosti su neophodni u velikom broju slučajeva i postoje različite metode koje se koriste u takve svrhe. Mnogobrojne studije ukazuju na to da razvoj trećeg molara može igrati ključnu ulogu u određivanju starosti osobe. Cilj studije bio je da se ispita mogućnost procene hronološke starosti na osnovu stadijuma razvoja trećeg molara kod dece i mladih u populaciji Srbije. **Metode.** Studijom je bilo obuhvaćeno ukupno 570 pacijenata iz Srbije uzrasta 6–27 godina. Od ukupnog broja ispitanika, 248 osoba bilo je muškog pola, prosečne starosti 12,21 ± 3,91 godina, dok su 332 osobe bile ženskog pola, prosečne starosti 12,88 ± 4,06 godina. Stadijumi dentalne zrelosti određeni su na ortopantomogramima poređenjem sa standardima po Demirjianu. **Rezultati.** Mineralizacija trećeg molara odvijala se brže kod muškaraca nego kod žena. Više osoba sa formiranim trećim molarima (stadijum razvoja H prema Demirjianu) bilo je starije od 18 godina. **Zaključak.** Određivanje stadijuma mineralizacije trećeg molara na ortopantomogramima je korisna metoda za određivanje hronološke starosti živih osoba. To može biti značajno za forenzička istraživanja, posebno zbog pravnog aspekta utvrđivanja odgovora na pitanje da li je osoba punoletna. Varijacije između različitih etničkih grupa moraju se uzeti u obzir kod primene ove metode. Neophodno je sprovesti obimnija istraživanja kako bi se odredili standardi za procenu dentalne i hronološke starosti stanovništva Srbije.

Ključne reči:
adolescenti; životno doba, određivanje po zubima; deca; stomatologija, sudska; molar, treći; radiografija, stomatološka; srbija.

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Introduction

Identification of persons and their age assessment are necessary in the number of cases, both in deceased individuals (airplane accidents, explosions, earthquakes, floods, fires), as well as in living persons (employment, retirement, wedding, voting right, health insurance, passport issuance and visa) [1]. To differentiate juvenile and adult status in criminal law cases, it is important to consider the age calculation[2]. The children and young adults chronological age estimation can be done by different methods that include: radiographic finding of the hand, radius and ulnar epidermis maturity, the combination of the cranial sutures as well as the assessment of secondary sexual characteristics [2]. Teeth could be considered as an indicator of person chronological age as well.

Such determinations are required in various clinical and scientific disciplines, such as orthodontics, pediatric dentistry, archeology and forensic dentistry [3]. The development of teeth is not only applicable for the age estimation as an addition to other parameters, but can be used as standalone parameter. Since teeth are the most resistant organs in the body, they survive significantly longer than other structures, even in the cases when bones and other tissues are distroyed [4]. By means of dental emergence or tooth formation stages observed in radiographs, the children's dental age can be estimated [5]. Numerous methods for the determination of the dental development from radiographs have been described [6, 7].

The most widespread method for the dental age estimation was initially described by Demirjian et al. [8] in 1973. It was based on a sample of French-Canadian children. They used eight stages of the crown and root development, denoting them with the letters of English alphabet from A to H. Until today this procedure has been tested in many populations all around the World and it is proven to be very applicable when it comes to Caucasian children [9, 10].

After the age of 14, age estimation becomes hindered given that all the permanent teeth, except the third molar, would have completed their development, rendering them to be the only clue used for age estimation [11].

The most common age involved in civil and criminal cases is 18 years. The hand and wrist development ends around the age of 18, while the development of third molars tends to continue over a longer period of time, even when the development of all other teeth is completed [2]. Third molars vary in size, formation time, outburst time, as well as in their position. Regardless of the previously mentioned facts, the third molar is the most stable biological indicator that can be used for determining the chronological age in adolescents aging from 15 to 25 [12, 13].

Several studies have been conducted in different populations to analyze whether the third molar was a reliable age indicator [14–18]. The studies concluded that dental development varies between different populations, indicating that population specific studies are necessary. The initial hypothesis was that Serbian children's rhythm of third molar maturation differentiates from that of the children in other countries where the standards were derived.

The aim of the study was to correlate chronological age with dental age based on the development of third molars in Serbian children and young adults and to compare third molar development by sex and age.

Methods

In this cross-sectional study, panoramic dental radiographs (orthopantomograms-OPGs) of 800 Serbian subjects with known chronologic age and sex were selected. Thirty-four films and 195 films were excluded because of poor radiographic quality and agenesis of the third molars, respectively. The final sample, consisted of 570 orthopantomograms from Serbian individuals aged 6–27 years were chosen for this study. There were 248 males with an average age of 12.21 ± 3.91 years, and 332 females with an average age of 12.88 ± 4.06 years. Additional data used for further statistical analysis were collected from patients' anamneses, clinical examinations and OPGs.

Subjects involved in this study did not have any medical history, as they had normal growth and dentition development. All OPGs were without image deformation. The subjects with anodontia, hiperdontia, hipodontia and/or narrowness were excluded from the study.

Examination and classification covered the development phase of the third right mandibular molar. Stages of dental formation in mandible were determined on OPGs by comparing the third molar appearance with radiographic appearance given by Demirjian et al. [8]. The third molar was scored "A" to "H" depending on the stage of calcification: A – Observed calcified areas of occlusal surface without their fusion; B – Fusion of the calcified areas occlusally, occlusal surface contoures recognizable; C – Calcification of the crown completed, dentine accumulation can be observed; D – Crown formation is completed to the enamel cemental junction; E – Radicular length is shorter than height of the crown; F – Radicular length is longer than height of the crown; G – Root formation is completed, apical opening is wide; H – Apical opening is closed, the periodontal membrane has a uniform width around the root and the apex.

Statistical analysis

The third molar formation process in mandible was examined using the Demirjian method and the obtained data were presented as mean values, standard deviation (SD), and range of chronologic ages for the eight stages of dental development. The comparison of ages between sexes was done by the Students *t*-test and Man-Whitney test. Statistical analysis was performed using SPSS V 15.0 program.

To test the reproducibility of the assessments of dental development stage, two investigators reevaluated randomly selected OPGs from 10% of the same subjects two months after the first evaluation. Inter- and intraobserver agreements were determined using the Wilcoxon matched-pairs signed-rank test.

Results

Repeated scorings of a subsample of 57 radiographs indicated no significant intra- or interobserver differences ($p > 0.05$). The intraobserver agreement was 96%, while the interobserver agreement was 95%.

The third-molar formation process was examined in both sexes, and the average ages ± SD for the Demirjian stages are given in Table 1, while mean values of dental age for both sexes are presented in Figure 1.

In males, mandibular third molar development commenced around 8.99 years, the root calcification started at 14.20 years and was completed by 20.87 years. In females third molar development started at 9.16 years, the root calcification started at 14.49 years and was completed at 21.11 years (Table 1).

In the present study development of the third molar in all stages was found slightly earlier in males than in females but the difference was not statistically significant ($p > 0.05$). The linear regression coefficient was provided to assess the correlation of the third molar development and chronologic age. Statistical analysis showed a strong correlation between age and the third molar development for both males (r = 0.62) and females (r = 0.63).

Regression formulas for the entire sample, as well as males and females separately, based on the number of third molar present were estimated (Whole sample: Age = 9.21 + 1.65 stage; Males: Age = 10.15 + 1.67 stage; Females: Age = 9.65 + 1.50 stage).

A comparative view of results of this study on the third molar formation in the Serbian population with those in other populations published earlier in the literature, is shown in Table 2.

Table 1

Descriptive values and statistical comparisons of Demirjian stages in the third molar formation in both sexes in the Serbian population

Demirijan stages*	Male			Female			*p*
	n	mean ± SD	min–max	n	mean ± SD	min–max	
A	34	8.99 ± 0.94	7.37–12.08	29	9.16 ± 1.26	7.49–13.49	ns
B	43	9.63 ± 1.11	7.81–12.56	48	9.90 ± 1.58	7.03–15.78	ns
C	39	10.27 ± 1.19	7.91–12.50	33	9.46 ± 0.83	7.81–10.99	ns
D	59	11.35 ± 2.03	6.11–15.35	77	11.70 ± 1.80	8.63–18.27	ns
E	25	14.02 ± 3.09	9.01–26.79	65	14.49 ± 2.93	7.22–23.29	0.01*
F	12	15.69 ± 1.23	13.92–17.46	24	14.93 ± 2.26	9.11–18.53	ns
G	16	17.77 ± 2.22	14.23–21.35	18	16.83 ± 3.47	10.63–21.74	ns
H	20	20.87 1.52	18.64–22.36	28	21.11 ± 3.21	18.26–26.58	ns

SD – standard deviation; *$p < 0.01$; ns – not significant.

***A – Observed calcified areas of occlusal surface without their fusion; B – Fusion of the calcified areas occlusally, occlusal surface contoures recognizable; C – Calcification of the crown completed, dentine accumulation can be observed; D – Crown formation is completed to the enamel cemental junction; E – Radicular length is shorter than height of the crown; F – Radicular length is longer than height of the crown; G – Root formation is completed, apical opening is wide; H – Apical opening is closed, the periodontal membrane has a uniform width around the root and the apex.**

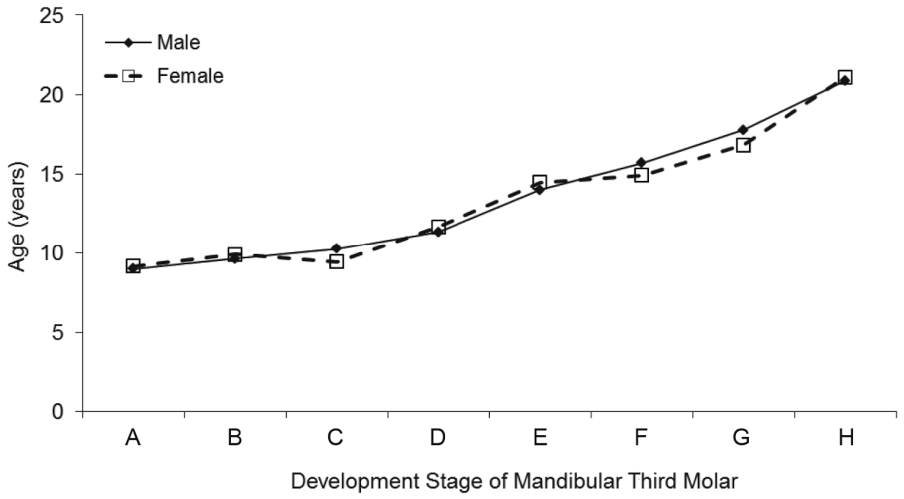

Fig. 1 – Mean ages of males and females in the Serbian population with different mandibular third molar development according to the Demirjian stages*. (*for explanation see under Table 1).

Table 2
Mean values and standard deviations (SD) in different populations estimated by the Demirijan method

Demirijan		German (Olze et al. [32])		Japanese (Olze et al. [32])		Spanish (Prieto et al. [14])		South African (Olze et al. [32])		Turkish (Sisman et al. [2])		Serbian (Present Study)	
stage*	Gender	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
D	M	16.3	3.1	18.2	3.3	15.08	1.04	15.08	1.04	12.9	1.5	11.35	2.03
	F	15.5	2.6	18	2.8	15.11	1	15.11	1	13.6	2.24	11.70	1.80
E	M	16.7	2.3	18.5	2.7	15.22	1.03	15.2	2.4	14.42	1.69	14.02	3.09
	F	16.8	2.3	18.6	2.3	16	1.43	15.9	2.3	15.42	2.4	14.49	2.93
F	M	18.3	2.2	20.4	2.4	16.42	1.34	18.7	2.3	16.9	1.5	15.69	1.23
	F	19.1	2.5	20.5	2.2	16.3	1.56	21.3	2.5	16.84	2.1	14.93	2.26
G	M	20.6	2.4	21.8	2.5	17.92	1.5	20.8	2.2	18.08	2.38	17.77	2.22
	F	21.7	2.1	21.8	2	18.41	1.44	19	2.3	19.29	2.32	16.83	3.47
H	M	22.7	1.9	22.7	2	19.74	1.09	22.6	1.9	22.1	2.87	20.87	2.22
	F	23	1.8	22.4	2.1	19.66	0.98	22.4	1.9	22.66	2.18	21.11	3.21

***For explanation see under Table 1.**

Discussion

Chronological age estimation based on teeth development has been used over a long period of time. Dental age estimation is particularly valuable given that teeth are highly resistant to mechanical, chemical or physical impacts and time. Dental aging was particularly used and received considerable attention within the field of dental anthropology, as well as in forensic medicine [20] and criminal law cases [2]. Since the increased number of adolescents and young adults with unknown date of birth is a current issue in justice and legal medicine, it is important to determine whether an individual was 18 years of age or older at the time the crime was committed [21, 22].

There have been a great number of different classifications (Gleiser and Hunt [23], Kullman [24]). However, the most frequently used one was given by Demirjian et al.[8] The Demirjian method is one of the simplest, the most effective and widespread methods. The advantage of this method is reflected in eight clearly defined stages and a precisely described changes occurring in crown and root shape within each stage. Liversidge et al. [25] reported that using Demirjian method one yields overestimated results, probably due to a positive trend in growth and development during the last 20–25 years. In children of the same chronological maturity, one can, very often, notice differences in various body parts growth and development rates. This is why biological age is defined, demarked by different stages in child development and maturity, whereas chronological age only roughly estimates child maturity [26]. Third molar development is important for dental age estimation in childhood, adolescence and in early adulthood. Several studies showed that chronological stages of wisdom molar mineralization vary slightly between different populations and races [10, 12, 27].

This study was strictly conducted on mandibular molars because in the evaluation of the maxillary molars a problem can arise due to the superposition of maxillary sinuses or maxillary tubes over the root of the molar. In the current study, no major differences could be analyzed between the different stages of root development, except for that boys were ahead of girls. The boys' teeth were reported to be calcified earlier than those of girls. Similar observations were noticed by numerous investigators [1, 2, 20, 28–31].

These observations are distinguishable from those of Kullman [24], who observed significant sex differences in 4 stages of root development. Rai et al. [32] found that third molar was calcified earlier in females. Levesque et al. [30] reported that besides being ahead of girls in the root development, the course of development was also faster in boys. This finding matches the results of the present study. It is surprising and unique for the third molar. A faster development for girls is usually seen for other permanent teeth.

When comparing these results with those in the Turkish [2], Japanese [19], German [19] and Spanish [14] population, the greatest similarities are seen with those from the Turkish one.

The study conducted on the Spanish population [14], with subjects 14–21 years old, showed that the wisdom teeth reached the same stages earlier than in the Scandinavian, American, German, Japanese and South African population. Comparing results of that study with the ones obtained here, it is clear that third molars development occurs earlier in the Serbian population.

Uzamiş et al. [33] found that the calcification of third molars begins between the age of 7 and 19 years in the Turkish population. It was also shown that the process of molar mineralization starts at the age of 8, and 12 months earlier in male than in female children. These results are similar with results of Sisman et al. [2] and Naik et al. [20]. On the other hand, the third molar development among the North India population was found to occur earlier relative to other populations and that there is a strong correlation between age and the third molar development for both sexes [32].

Authors of a study that included only males aged 13–23 years from the Saudi Arabian population, reported only mandible third molars development because there were no maxillary third molars in majority of subjects [34]. They also

reported that the difference between chronological and dental maturity ranged from 0.76 to 2.0 years, and concluded that the stage A of the third molars development was at 13.29 ± 0.76 years, while the stage H was at 22 ± 1.77 years [34].

Our results indicate that the Serbian population reaches the stage H at mean age of 20.87 years in males and 21.11 years in females. Orhan et al. [22] found that the Turkish population reaches the stage H at mean age of 20.1 years. Sisman et al. [2], in a study conducted also in the Turkish population, demonstrated that the stage H was reached at mean age of 22.1 years in males and 22.6 years in females. Results reporting the probability of an individual being older than 18 (at the stage H) are in accordance with previous studies [2, 14, 16, 35].

Rani Hamsa et al. [36] in a study that included males and females, children and adolescents at age of 8–23 years found that there was no difference between males and females in stages A, B, E, F, G and H. However, in stages C ($p < 0.05$) and D ($p < 0.01$), they reported that mineralization was occurring earlier in females than in males. On the other hand Golovencu et al. [27] estimated that in subjects from the Romanian population aged 11–25 years, no significant differences existed between the development of wisdom teeth in both sides of the jaws. The root calcification started at 15.1 years and was completed by 19.3–20 years [37].

Conclusion

Demirjian method could play an important role in determining the age of persons who need to be identified for different reasons.

In the Serbian population, third molars mineralization occurs earlier than in other population for almost all stages. Third molars mineralization occurs more rapidly in males than in females. Large percentage of persons with the third molar (the stage H) is older than 18 years, which might be important fact for forensic studies.

It is necessary to carry out extensive surveys on a larger sample in order to determine the norms for assessing the dental and chronological age within Serbian population.

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