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ORIGINAL ARTICLE

Willems I and Willems II Methods for Dental Age Assessment in Children and Adolescents aged 3–16 years in the Varanasi Region: Applicability and Comparability

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Abstract:

In order to create new, simplified tables (Willems I method) for males and females in the Belgian Caucasian population, Willems G et al. (2001) reexamined Demirjian's technique. With these tables, dental age can be represented directly in years without the need for additional conversion tables. Using the prior data and a new study group, Willems G et al. (2010) created a common table for males and females to overcome cases of unknown gender and created a non-gender-specific method (Willems II method) that was not gender-specific. This study aims to evaluate the Willems I and Willems II methods for age estimation in a sample of the Varanasi region population. In this cross-sectional study, 432 samples (237 boys and 195 girls of age range 3–16 years) from the population of Varanasi region were evaluated to validate the Willems I and Willems II age estimation methods. A paired t-test was applied to determine the statistical significance between estimated dental age and chronological age. The Willems I method underestimated the dental age in boys by -0.27 ± 0.80 years and in girls by -0.60 ± 0.95 years. The Willems II method also underestimated the age by -0.57 ± 0.86 years in boys and -0.38 ± 0.93 years in girls. Pearson correlation revealed a strong positive association in both methods. The Willems I and Willems II methods are not exactly applicable, but the Willems I method is more relatable to the actual age of the boys sample and the Willems II method for the girls sample.

Keywords: Age estimation; Dental age; Tooth Development; Willems I method; Willems II method.

Introduction:

Age estimation is one of the most common concerns in the personal identification of both living and deceased people. Estimating age is necessary to identify guilty, innocent, and victims in criminal cases, civil cases, advanced decomposed bodies, skeletal remains, mutilated bodies, and victims of a mass disaster. Age is the basis for assessing whether a child can go to school, the applicability of criminal laws, and whether a child has attained the age of criminal responsibility. Its significance rises in cases of rape, abduction, marriage, work, early birth, criminal abortion, falsified or nonexistent birth certificate, undocumented immigration, pediatric care, orthodontic care, and other age-restricted areas.[1,2]

A wide variety of age estimation approaches have been developed, including the use of skeletal age, morphological age, sexual age, and dental age. The dental age estimation method is the most accurate and reliable among these methods because teeth have the lowest turnover of all body tissues, and their growth is regulated by genes, making them less vulnerable to dietary and environmental influences.[3] Mineralization of teeth is a more accurate measure of dental maturity than eruption since it is unaffected by factors including primary tooth loss, lack of space, malnutrition, dental decay, ankylosis, and some orthodontic abnormalities.[4] Orthodontists and pedodontists also use dental age. It also aids in the detection of hormonal abnormalities in children, such as growth hormone hyposecretion. Additionally, it gives orthodontists hints regarding when to start orthodontic therapy. Researching tooth mineralization has potential applications in numerous scientific and therapeutic domains, including orthodontics, pediatric dentistry, forensic dentistry, pediatric endocrinology, orthopedics, and comparative anthropological research.[3,4] Several radiographic methods have also been developed for dental age estimation, but the method developed by Demirjian et al.[5] based on the evaluation of orthopantomograms of French-Canadian children is the most widely used dental technique for determining dental age.[6] This is most likely because of its relative simplicity and accuracy, as well as its thorough description and radiographic pictures of the stages of tooth growth. Willems G et al.[7] updated and simplified Demirjian's approach by analyzing the Caucasian child population of Belgium in their research. Willems' improvement was found to be slightly more precise than Demirjian's original scale.[6]

This cross-sectional study aims to test and compare the accuracy of the Willems I (gender-specific) method[7] and the Willems II (non-gender-specific) method[8] in the Varanasi region population of 3–16 year-old age groups. To the best of our knowledge, none of the studies have been conducted using the Willems methods alone or in combination with other methods in Varanasi region population.

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Table 1. Showing the pearson`s correlation coefficient between estimated dental ages and chronological ages for the willems I and willems II methods.

Sample	Willems I		Willems II	
	Correlation (r)	Significance	Correlation (r)	Significance
Total boys (n = 237)	0.970	0.000	0.966	0.000
Total girls (n = 195)	0.952	0.000	0.955	0.000
Total sample (n = 432)	0.962	0.000	0.962	0.000

Significant difference p<0.05

Table 2. Paired t-test showing the mean differences between estimated dental ages using willems I and willem II methods and chronological ages for total boys, total girls and total sample.

Methods	Gender	Mean ± SD‖			95 % CI†† of (EDA – CA) **	p-value
		CA‡± SD	EDA§± SD‖	(EDA – CA)**± SD		
Willems I	Total boys (n=293)	10.16 ± 3.28	9.89 ± 3.21	-0.27 ± 0.80	-0.38, -0.17	0.000*
	Total girls (n=195)	11.37 ± 3.11	10.77 ± 2.91	-0.60 ± 0.95	-0.73, -0.47	0.000*
	Total Sample (n=432)	10.71 ± 3.26	10.28 ± 3.11	-0.42 ± 0.89	-0.51, -0.34	0.000*
Willems II	Total boys (n=293)	10.16 ± 3.28	9.59 ± 3.28	-0.57 ± 0.86	-0.68, -0.46	0.000*
	Total girls (n=195)	11.37 ± 3.11	10.99 ± 2.92	-0.38 ± 0.93	-0.51, -0.25	0.000*
	Total Sample (n=432)	10.71 ± 3.26	10.23 ± 3.20	-0.48 ± 0.89	-0.57, -0.40	0.000*

CA‡ = chronological age; EDA§ = estimated dental age; SD‖ = standard deviation; (EDA – CA) ** = mean age difference; CI†† = confidence interval
p* = statistically significant difference ($p < 0.05$)

Materials and Methods:

This cross-sectional study evaluates digital panoramic radiographs of 432 people, 237 boys and 195 girls, ages 3-16 years, from the Varanasi region of Uttar Pradesh who visited the Banaras Hindu University, Varanasi, Faculty of Dental Sciences, Institute of Medical Sciences. All the subjects who were selected were of Indian origin with a known date of birth, a known date of radiograph, and clearly visible teeth in radiographs without any dental anomalies. None of the cases were taken primarily for study purposes. In this study, written informed consent was obtained from the participants or parents of the participants. The date of birth of participants was confirmed by the author himself after matching with any identity card issued by competent authority, i.e. Aadhaar card or school identity card.

In Willems I and II methods, the evaluation of dental age is based on the Demirjian's eight stages of tooth development and mineralization of seven left mandibular teeth, namely the second molar (M_2), first molar (M_1), second premolar (PM_2), first premolar (PM_1), canine (C), lateral incisor (I_2), and central incisor (I_1), from calcification of the cusp to closure of the root apex (A to H stages). The Willems-I method is a gender-specific method in which each tooth was allocated a score from a self-weighed score table developed in this method for males and females separately, based on Demirjian's stages of tooth calcification and development. The sum of the scores directly gives the dental age, or estimated age. The Willems II method is a non-gender-specific method in which scores were allocated to each tooth based on Demirjian's stages of tooth calcification from the Willems non-gender-specific table, which is the same for both males and females. The sum of the scores directly gives the dental age, or estimated age, in this method as well. Chronological age was calculated by subtracting the date of the radiograph from the date of birth of the subject. Age was calculated in days, which were further converted to decimal age up to two decimal places in Microsoft Excel software.

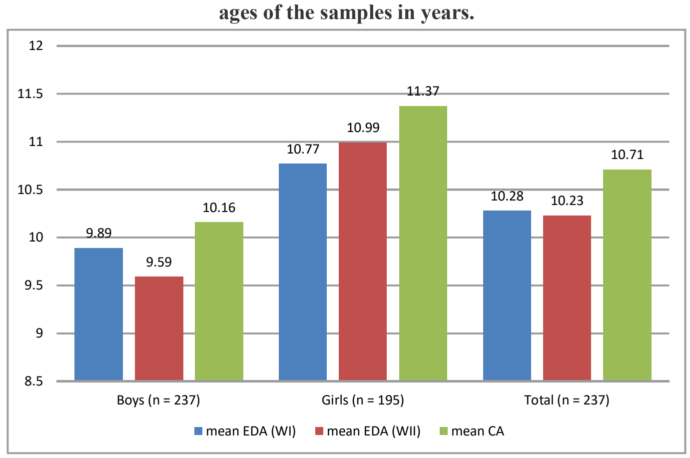
Statistical Analysis: The degree of inter and intra-observer agreement was assessed and calculated using Cohen`s Kappa statistics. The data were statistically analyzed using IBM SPSS version 24 software, according to the proposed study. A paired t-test was performed to determine the mean difference between estimated dental age and chronological age in the Willems I and Willems II methods. Pearson's correlation coefficient was calculated to establish the correlation at a 95% confidence interval. Statistical significance was set at $p < 0.05$.

Ethical approval: This study was approved by the ethical committee of the Institute of Medical Sciences, Banaras Hindu University (Ethical approval number: ECR/bhu/Inst/2013/Re-registration, 31.01.2017/Dean/2018/EC/585).

Results:

The average chronological ages in this study were 10.16 (±3.28) for total boys, 11.37 (±3.11) for total girls, and 10.71 (±3.26) for total samples. The mean estimated dental ages for all boys, all

Graph 1. Showing the mean estimated dental ages and mean chronological ages of the samples in years.



Graph 2. Showing the differences between mean estimated dental ages and mean chronological ages of the samples in years.

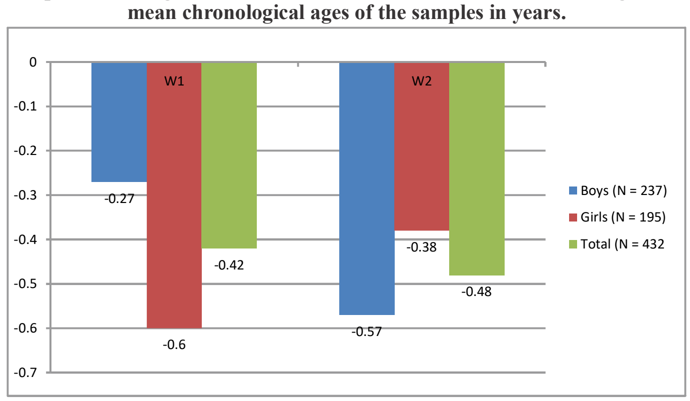


Table 3. Differences between estimated dental ages using Willems I method and chronological ages for specific age groups.

Age groups †	Sam-ples	Mean ± SD‖			95 % CI†† of (EDA – CA) **	p-value
		CA‡± SD	EDA§± SD‖	(EDA – CA)**± SD		
Boys						
3	7	3.64 ± 0.25	3.69 ± 0.18	0.05 ± 0.42	-0.34,0.43	0.767
4	10	4.57 ± 0.29	4.30 ± 0.44	-0.27 ± 0.47	-0.60, 0.07	0.102
5	14	5.52 ± 0.28	5.49 ± 1.05	-0.02 ± 0.96	-0.58, 0.53	0.926
6	20	6.38 ± 0.28	6.33 ± 0.36	-0.06 ± 0.28	-0.19, 0.08	0.398
7	13	7.54 ± 0.32	7.28 ± 0.55	-0.26 ± 0.56	-0.60, 0.08	0.117
8	19	8.48 ± 0.27	8.22 ± 0.79	-0.26 ± 0.74	-0.61, 0.10	0.149
9	25	9.51 ± 0.23	9.32 ± 0.79	-0.20 ± 0.77	-0.52, 0.12	0.212
10	28	10.50 ± 0.34	10.19 ± 0.83	-0.30 ± 0.82	-0.62, 0.02	0.061
11	22	11.53 ± 0.30	11.39 ± 1.03	-0.15 ± 0.85	-0.52, 0.23	0.433
12	22	12.45 ± 0.23	12.30 ± 0.71	-0.15 ± 0.74	-0.48, 0.18	0.356
13	28	13.43 ± 0.29	12.81 ± 1.04	-0.62 ± 1.02	-1.01, -0.23	0.003*
14	11	14.43 ± 0.24	14.09 ± 0.74	-0.34 ± 0.69	-0.80, 0.13	0.135
15	18	15.48 ± 0.33	14.66 ± 0.96	-0.82 ± 1.04	-1.34, -0.30	0.004*
Girls						
3	4	3.50 ± 0.30	3.42 ± 0.51	-0.08 ± 0.26	-0.49, 0.33	0.565
4	2	4.53 ± 0.13	5.32 ± 1.25	0.79 ± 1.37	-11.54, 13.12	0.565
5	9	5.53 ± 0.23	5.59 ± 0.60	0.06 ± 0.52	-0.34, 0.46	0.733
6	7	6.54 ± 0.32	6.40 ± 1.17	-0.14 ± 1.26	-1.30, 1.02	0.774
7	9	7.56 ± 0.31	7.34 ± 0.49	-0.22 ± 0.60	-0.69, 0.24	0.297
8	14	8.50 ± 0.32	8.02 ± 0.69	-0.48 ± 0.66	-0.86, -0.10	0.017*
9	15	9.51 ± 0.32	9.04 ± 0.43	-0.47 ± 0.45	-0.72, -0.22	0.001*
10	21	10.65 ± 0.25	9.95 ± 0.99	-0.70 ± 0.96	-1.14, -0.27	0.003*
11	19	11.48 ± 0.28	11.38 ± 0.83	-0.11 ± 0.80	-0.49, 0.28	0.565
12	24	12.55 ± 0.35	11.98 ± 1.31	-0.58 ± 1.23	-1.10, -0.06	0.032*
13	26	13.56 ± 0.29	12.61 ± 0.93	-0.95 ± 0.95	-1.34, -0.57	0.000*
14	22	14.46 ± 0.34	13.81 ± 0.81	-0.66 ± 0.77	-1.00, -0.31	0.001*
15	23	15.41 ± 0.25	14.01 ± 0.80	-1.41 ± 0.84	-1.77, -1.04	0.000*

†Age group 3 means: 3.00 – 3.99 years and so on
CA‡ = chronological age; EDA§ = estimated dental age; SD‖= standard deviation; (EDA – CA) ** = mean age difference; CI†† = confidence interval
p* = statistically significant difference ($p < 0.05$)

Table 4. Differences between estimated dental ages using Willems II method and chronological ages for specific age groups.

Age groups †	Sam-ples	Mean ± SD‖			95 % CI†† of (EDA – CA) **	p-value
		CA‡± SD	EDA§± SD‖	(EDA – CA)**± SD‖		
Boys						
3	7	3.64 ± 0.25	2.64 ± 0.39	-1.00 ± 0.36	-1.33, -0.67	0.000*
4	10	4.57 ± 0.29	3.57 ± 0.81	-1.00 ± 0.90	-1.64, -0.35	0.007*
5	14	5.52 ± 0.28	5.43 ± 1.01	-0.08 ± 0.91	-0.61, 0.44	0.738
6	20	6.38 ± 0.28	6.21 ± 0.32	-0.17 ± 0.30	-0.31, -0.03	0.019*
7	13	7.54 ± 0.32	7.03 ± 0.51	-0.51 ± 0.55	-0.84, 0.18	0.006*
8	19	8.48 ± 0.27	7.92 ± 0.83	-0.55 ± 0.78	-0.93, -0.18	0.006*
9	25	9.51 ± 0.23	9.01 ± 0.78	-0.50 ± 0.77	-0.82, -0.19	0.003*
10	28	10.50 ± 0.34	9.87 ± 0.78	-0.63 ± 0.78	-0.93, -0.32	0.000*
11	22	11.53 ± 0.30	11.07 ± 1.11	-0.46 ± 0.94	-0.88, -0.05	0.030*
12	22	12.45 ± 0.24	12.03 ± 0.89	-0.43 ± 0.92	-0.83, -0.02	0.042*
13	28	13.43 ± 0.29	12.59 ± 1.07	-0.84 ± 1.06	-1.25, -0.43	0.000*
14	11	14.43 ± 0.24	13.87 ± 0.76	-0.56 ± 0.71	-1.04, -0.08	0.026*
15	18	15.48 ± 0.33	14.41 ± 1.01	-1.07 ± 1.11	-1.62, -0.52	0.001*
Girls						
3	4	3.50 ± 0.30	3.06 ± 0.63	-0.45 ± 0.35	-1.01, 0.12	0.085
4	2	4.53 ± 0.13	5.56 ± 1.36	1.03 ± 1.49	-12.31, 14.37	0.506
5	9	5.53 ± 0.23	5.63 ± 0.58	0.10 ± 0.49	-0.27, 0.47	0.549
6	7	6.54 ± 0.32	6.52 ± 1.17	-0.02 ± 1.25	-1.17, 1.14	0.970
7	9	7.56 ± 0.31	7.65 ± 0.48	0.08 ± 0.60	-0.38, 0.54	0.690
8	14	8.50 ± 0.32	8.33 ± 0.57	-0.17 ± 0.55	-0.48, 0.15	0.267
9	15	9.51 ± 0.32	9.38 ± 0.51	-0.13 ± 0.51	-0.42, 0.15	0.329
10	21	10.65 ± 0.25	10.27 ± 0.93	-0.39 ± 0.89	-0.80, 0.02	0.059
11	19	11.48 ± 0.28	11.66 ± 0.79	0.18 ± 0.75	-0.19, 0.54	0.322
12	24	12.55 ± 0.35	12.24 ± 1.27	-0.31 ± 1.19	-0.82, 0.19	0.213
13	26	13.56 ± 0.29	12.82 ± 0.88	-0.75 ± 0.91	-1.11, -0.38	0.000*
14	22	14.46 ± 0.34	13.97 ± 0.79	-0.49 ± 0.75	-0.82, -0.15	0.006*
15	23	15.41 ± 0.25	14.18 ± 0.75	-1.23 ± 0.79	-1.58, -0.89	0.000*

†Age group 3 means: 3.00 – 3.99 years and so on
CA‡ = chronological age; EDA§ = estimated dental age; SD‖ = standard deviation; (EDA – CA)** = mean age difference; CI†† = confidence interval
p* = statistically significant difference ($p < 0.05$)

girls, and all samples were 9.89 (±3.21), 10.77 (±2.91), and 10.28 (±3.11) years, respectively, when using the Willems-I approach. The mean difference between estimated dental age and chronological age for the total sample analyzed was -0.42 (±0.89) years; for total boys, it was -0.27 (±0.80) years; and for total girls, it was -0.60 (±0.95) years, respectively, with a statistically significant value ($p < 0.05$) in both genders and total sample (Table 2). For boys, the differences were statistically significant in age groups 13 and 15, while for girls, they were significant in age groups 8–10 and 12–15 ($p < 0.05$). There were no statistically significant differences found in the remaining age categories for both genders (Table 3). The mean estimated dental age, as determined by the Willems II method, was 9.59 (±3.28) years for total boys, 10.99 (±2.92) years for total girls, and 10.23 (±3.20) years for the combined samples. For total boys, total girls, and total samples, the mean differences between estimated dental age and chronological age were -0.57 (±0.86), -0.38 (±0.93), and -0.48 (±0.89) years, respectively, and significant differences were found ($p < 0.05$) for each of them (Table 2). With a p-value < 0.05, the statistically significant differences were found for females in particular age categories of 12–15 years and boys in all age groups with the exception of a particular age group of 5 year (Table 4). According to Table 1, Pearson's correlation coefficient showed a significant positive association between boys, girls, and the population as a whole in both methods.

Discussion:

In this study, 432 samples, including 237 boys and 197 girls, were evaluated for dental age estimation using the Williams I and Willems II methods. Early dental development is indicated by a positive mean difference, whereas delayed dental development is indicated by a negative mean difference. In the Willems I method, negative mean age differences were observed in total boys, total girls, and total samples by -0.27 (±0.80), -0.60 (±0.95), and -0.42 (±0.89) years, respectively. In boys, all specific age groups (except 3) and in girls, all specific age groups (except 4 and 5) are delayed in dental development. In the Willems II method, delayed dental age was also observed by -0.57 (±0.86), -0.38 (±0.93), and -0.48 (±0.89) years in total boys, total girls, and total sample, respectively. In boys, all specific age groups, and in girls, all specific age groups (except 4, 5, 7, and 11) reported delayed dental development. The total samples of boys, girls, and combined form and majority of specific age groups in both approaches showed negative mean age differences when compared to chronological ages, indicating delayed dental development and the remaining age groups showing early dental development. A recent study conducted in the Indian population by Hegde S et al.[9] reported overestimation of age in males by 0.09 years, in females by 0.08 years, and in the total sample by 0.09 years using the Willems I method, overestimation of age in males by 0.11 years, total sample by 0.01 years, and underestimation of age by -0.06 years in females using the Willems II method. No statistically significant difference was present for males, females, or the total sample. Urzel et al.[10] conducted a study on the French population and compared the Willems I and Willems II methods. In Willems, I, overestimation of age in the male by 0.14 years and underestimation by -0.09 years, and in Willems II method, no mean difference was reported in the total sample. Ortega-Pertuz AI.[11] on Venezuelan children reported overestimation of age in boys by 0.21 years and underestimation in girls by 0.03 years using the Willems I method, and overestimation of age in both boys and girls by 0.06 years and 0.18 years, respectively, using the Willems II method. All these studies have reported different results from our study.

When we consider only the Willems I method of our study which shows delayed dental development and the result was in agreement with studies conducted by Mohammad RB et al.[12] and Priya E.[13] in the Indian population, Ranasinghe S et al.[14] in the Sri Lankan population, Lee SS et al.[15] in Korean children, Zhai Y et al.[16] in Chinese children, and Kelmendi et al.[4] in Kosova children. This result was contradicted by Rai B et al.,[17] Gupta et al.,[18] Kumar Vinod et al.,[19] Shekhar Grover et al.[20] and Akbar A et al.[21] in the Indian population, and El Bakary AA et al.[22] in the Egyptian population. Djukic K et al.[6] in the Serbian population, Javadinejad S et al.[23] in the Iranian population, Mani SA et al.,[24] Nik-Hussein NN et al.[25] and Yousof MY et al.[26] in Malaysian children, Amberkova V et al.[27] in the Former Yugoslav Republic of Macedonia, Medina AC et al.[28] in Venezuelan children, Galie I et al.[29] in Bosnian and Herzegovian children, Franco A et al.[30] in Brazilian children, Maber M et al.[31] in British Caucasian and Bangladeshi children, and Cortés MM et.[32] in Spanish children have reported overestimation in dental age. Some studies show partial agreement, as conducted by Metasannity M et al.[33] in Somali children, the study reported overestimation of age in males, underestimation in females, and total population; Ramanan N et al.[34] in the Japanese population reported overestimation of age in males and underestimation of age in females; Cameriere R et al.[35] a combined study of Italian, Spanish, and Croatian children, reported overestimation of age in boys by 0.247 years and underestimation of age in girls by 0.073 years.

The differences observed while comparing our results with other studies from different areas may be due to sampling size, sampling method, and biological variation in children, ethnicity, geographical location, environmental factors, nutrition, socioeconomic status, and the time difference between the two studies.[12,36] The results of this study are somewhat relevant to the forensic context, even if the mean difference between estimated age and chronological age is within the range of ±0.5 or ±1.0 years, which is thought to be an acceptable range for forensic anthropology.[12]

Conclusions:

The differences in the mean estimated dental age and chronological age are statistically significant for the total boys, total girls, and total samples and showing delayed dental development in the Willems I and Willems II methods; therefore, none of them is accurate. However, findings in this study reveal that the Willems I method is more relatable to actual age for boys and the Willems II method for girls. Both methods are prone for underestimation of dental age; therefore, it is required to develop a population-specific methodology for dental age estimation in the Varanasi region.

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