Dental age estimation using Willems method: A cross-sectional study on children in a North Indian city

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Abstract

Background: Numerous methods of age estimation have been proposed. The Demirjian method which was first applied in a French-Canadian population in 1972 is the most frequently used dental age estimation method. However, a constant over estimation using this method has been reported by numerous researchers. The Willems method is a modification of the above and was first applied in a Belgian Caucasian population in 2002. Several studies in the recent years found Willems method to be more accurate than the original Demirjians method.

Objectives: The objective of this study was to evaluate the applicability of Willems method for dental age estimation in 6 -15-year-old North Indian children.

Methods: The sample for this cross sectional study consisted of 390 OPGs of (215 boys and 175 girls) randomly selected from the patient records of a post graduate training dental college in North India. Exact chronological age of the subjects (in years and months) was calculated. The OPGs were used to score the seven mandibular teeth and dental age was estimated using the tables proposed in Willems method.

Results: Significant correlation between the chronological age and dental age estimated using Willems method was observed in both males ($r = 0.90$) and females ($r = 0.87$). The mean difference between estimated DA and CA for males was 0.004 ± 1.08 years ($P = 0.94$). While for females, it was 0.031 ± 1.18 years ($P = 0.72$). The results showed no statistically significant difference between chronological age and dental age estimated using Willems method in the study population.

Conclusion: Willems dental age estimation method without any modification can predict the chronological age of 6-15 year old North Indian children with good accuracy.

Keywords: Dental age estimation, North Indian children, Willems method

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INTRODUCTION

Dental age estimation methods have established themselves as an imperative and handy tool in the field of forensic odontology and an impending standard in orthodontic treatment planning. The different means of dental age estimation to determine the age of living persons and corpses include the morphological, biochemical and radiographic methods.

Radiological evaluation of the development of crown and root of growing teeth is the most common method

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to estimate dental age in children and adolescents.[1] The estimation of age based on the calcification of the permanent teeth has been demonstrated to provide reliable and accurate results.[2] Different radiological methods are available for estimating the dental age as advanced by Nolla,[3] Haavikko (1974)[4] and Demirjian *et al.* (1973).[5] Among many proposed methods, Demirjian system of age assessment has been widely accepted.[6,7] The advantages of the Demirjian method include the objective criteria describing stages of tooth development, which have been illustrated with line diagrams and radiographic images in a clear-cut manner.[8]

The original Demirjian method was developed based on the study of a French-Canadian population. Numerous researchers reported a significant and consistent overestimation when this method was applied to their respective populations.[9-13] Willems *et al.* modified the Demirjian method based on a Belgian Caucasian population and simplified the age estimation by directly converting maturity scores into age. The modified technique resulted in smaller overestimation of 0.0 years in males and 0.2 years in females.[14]

Several studies in the recent years found Willems method to be more accurate than the original Demirjian method.[15-19] There are limited studies on the applicability of Willems method of age estimation among Indian children. Therefore, the aim of the present study was to evaluate the applicability of Willems method of dental age estimation in children from Ludhiana city in the North Indian state of Punjab.

MATERIALS AND METHODS

The methodology of the study involved the following steps:
1. Sample selection and inclusion criteria
2. Calculation of chronological age
3. Estimation of dental age
4. Statistical analysis.

Sample selection

The sample consisted of 390 digital orthopantamograms of children (215 boys and 175 girls, ages ranging from 6 to 15 years) selected from the patient record database of the Department of Oral and Maxillofacial Radiology of a postgraduate training dental institute. The radiographs were obtained using VATECH PAX-I DIGITAL OPG M/C X-ray equipment.

The children included in the study were free from any past prolonged illness and had neither undergone previous orthodontic treatment nor extraction of any permanent teeth and were residing in the state of Punjab for at least the last three generations (as obtained through parental interview and medical records). Children with chronological age above 15 years, with incomplete records, congenital anomalies, systemic diseases and unclear orthopantomograms were excluded from the study.

Calculation of chronological age

Exact chronological age of the child (in years and months) was calculated by subtracting the date of birth from the date on which radiographs were exposed for that particular child and was expressed as years with two decimal places.

Estimation of dental age

All potentially identifying information was blocked out and the radiographs were coded (1M, 2M, 3M…. etc. for males; 1F, 2F, 3F…. etc. for females) for identification purposes. The name and exact chronological age of the children and the code assigned to the respective radiographs were noted on a separate sheet. This was done to avoid bias during scoring of radiographs. All the assessments were made by a single examiner. A set of 30 radiographs were randomly selected and reassessed after a period of 4 weeks, and the two sets of observations were statistically analyzed to assess intra-examiner reliability. The development of the seven permanent left mandibular teeth (excluding the third molar) was determined from the panoramic radiograph. Tooth calcification was rated according to the method described by Demirjian *et al.*[5] into one of the eight stages of calcification, and dental maturation stage from A to H was assigned for each tooth. After assignment of a dental maturation stage for each tooth in the left mandibular

Table 1:WILLEM'S DIRECT AGE SCORES FOR DEVELOPMENTAL TOOTH STAGES BASED ON DEMIRJIAN'S TECHNIQUE FOR BOYS.

TOOTH	A	B	C	D	E	F	G	H
Central Incisor	_	_	1.68	1.49	1.5	1.86	2.07	2.19
Lateral Incisor	_	_	0.55	0.63	0.74	1.08	1.32	1.64
Canine	_	_	_	0.04	0.31	0.47	1.09	1.9
First premolar	0.15	0.56	0.75	1.11	1.48	2.03	2.43	2.83
Second premolar	0.08	0.05	0.12	0.27	0.33	0.45	0.4	1.15
First molar	_	_	_	0.69	1.14	1.6	1.95	2.15
Second molar	0.18	0.48	0.71	0.8	1.31	2	2.48	4.17

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quadrant, the stages were converted into scores by referring to the conversion tables given by Willems *et al*.[6] [Tables 1 and 2]. The dental age was obtained by adding the individual scores of seven teeth.

Statistical analysis

Intra-examiner reliability between first and second reading for parametric data (dental age) was determined using intraclass correlation coefficient and Dahlberg's formula for measurement of error reproducibility. Measurement of agreement for nonparametric data (tooth calcification stage) was done by determining the Cohen's kappa value. All children were divided into groups according to the chronological age (6–6.99, 7–7.99, 8–8.99.....14–14.99 years), and descriptive statistics were obtained by calculating the mean and standard deviation of the chronological age and dental

Table : 2 WILLEM'S DIRECT AGE SCORES FOR DEVELOPMENTAL TOOTH STAGES BASED ON DEMIRJIAN'S TECHNIQUE FOR GIRLS.

TOOTH	A	B	C	D	E	F	G	H
Central Incisor	_	_	1.83	2.19	2.34	2.82	3.19	3.14
Lateral Incisor	_	_	_	0.29	0.32	0.49	0.79	0.7
Canine	_	_	0.6	0.54	0.62	1.08	1.72	2
First premolar	- 0.95	- 0.15	0.16	0.41	0.6	1.27	1.58	2.19
Second premolar	- 0.19	0.01	0.27	0.17	0.35	0.35	0.55	1.51
First molar	_	_	_	0.62	0.9	1.56	1.82	2.21
Second molar	0.14	0.11	0.21	0.32	0.66	1.28	2.09	4.04

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Table 3: Comparison between dental age using Willems method and chronological age in years among boys

Age groups	*n*	CA±SD	DA±SD	(DA-CA)±SD	L	U	*t* (df)	*P*
6-6.99	11	6.61±0.22	6.95±1.02	0.33±0.89	0.93	0.26	1.242 (10)	0.243
7-7.99	15	7.47±0.21	7.33±0.88	−0.13±0.76	0.28	0.56	0.702 (14)	0.494
8-8.99	17	8.49±0.31	8.62±1.19	0.13±1.21	0.75	0.48	0.452 (16)	0.657
9-9.99	29	9.44±0.28	9.55±0.51	0.10±0.59	0.32	0.12	0.926 (28)	0.362
10-10.99	28	10.43±0.31	10.11±0.68	−0.31±0.76	0.02	0.61	2.213 (27)	0.036
11-11.99	30	11.38±0.27	11.14±0.96	−0.24±0.96	0.11	0.60	1.385 (29)	0.177
12-12.99	24	12.37±0.29	12.33±1.00	−0.03±1.00	0.38	0.46	0.176 (23)	0.861
13-13.99	32	13.55±0.30	13.83±1.67	0.28±1.66	0.88	0.31	0.959 (31)	0.345
14-14.99	29	14.41±0.32	14.49±1.26	0.08±1.25	0.55	0.39	0.344 (28)	0.733
Total	215	11.09±2.36	11.10±2.61	0.004±1.08	0.151	0.141	0.64 (214)	0.90

DA: Dental age, CA: Chronological age, DA-CA: Difference between dental and chronological age, SD: Standard deviation, df: Degrees of freedom, *t* value: Paired *t*-test between DA and CA, L: Lower interval, U: Upper interval of 95% CI of DA-CA, CI: Confidence interval

Table 4: Comparison between dental age using Willems method and chronological age in years among girls

Age groups	*n*	CA±SD	DA±SD	(DA-CA)±SD	L	U	*t* (df)	*P*
6-6.99	7	6.65±0.31	7.42±0.97	0.77±0.86	1.57	0.03	2.345 (6)	0.57
7-7.99	6	7.60±0.28	8.16±0.92	0.55±1.06	1.67	0.55	1.284 (5)	0.255
8-8.99	10	8.53±0.27	8.23±0.89	−0.30±0.92	0.36	0.96	1.030 (9)	0.330
9-9.99	21	9.39±0.28	9.32±0.77	−0.07±0.79	0.28	0.43	0.415 (20)	0.683
10-10.99	23	10.38±0.27	10.20±0.79	−0.17±0.80	0.17	0.52	1.056 (22)	0.302
11-11.99	21	11.41±0.35	11.23±1.09	−0.17±1.08	0.31	0.67	0.754 (20)	0.460
12-12.99	35	12.37±0.25	12.62±1.34	0.24±1.22	0.66	0.17	1.188 (34)	0.243
13-13.99	28	13.51±0.27	13.53±1.75	0.01±1.62	0.64	0.60	0.064 (27)	0.949
14-14.99	24	14.41±0.30	14.41±1.35	−0.005±1.34	0.56	0.57	0.020 (23)	0.984
Total	175	11.49±2.17	11.52±2.45	0.031±1.18	0.20	0.14	0.348 (174)	0.72

DA: Dental age, CA: Chronological age, DA-CA: Difference between dental and chronological age, SD: Standard deviation, df: Degrees of freedom, *t* value: Paired *t*-test between DA and CA, L: Lower interval, U: Upper interval of 95% CI of DA-CA, CI: Confidence interval

Table 5: Intra-rater agreement of Demirjian's stages of tooth mineralization with inter-class coefficient of dental age for 30 randomly selected OPGSs

	Central incisor	Lateral incisor	Canine	Premolar 1	Premolar 2	Molar 1	Molar 2
Kappa values	0.464	0.529	0.900	0.713	0.778	1.000	0.910
P	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Interpretation of kappa (strength of agreement) according to Altman

0.00-0.20: slight (poor) 0.21- 0.40: fair 0.41- 0.60: moderate 0.61- 0.80: substantial 0.81- 1.00: almost perfect

ICC (95% CI) = 0.991 (0.981 - 0.996) Method Error Dahlberg Formula = 0.282

ICC: Inter-class coefficient, CI: Confidence interval, OPGS: Orthopantamograms

age for males and females separately of all age groups and a combined difference of males and females of all considered groups. The interrelationship between chronological age and dental age was determined by calculating the Pearson's correlation between means of both. The significance of these correlations was also analyzed.

RESULTS

The distribution of 390 children (215 boys and 175 girls) is shown in Tables 3 and 4. The intra-rater agreement for stages of dental maturation of 30 randomly selected orthopantamograms varied from 0.46 for the central incisor to 1.0 for the first molar. The inter-class coefficients of intra-rater agreement of dental age of the same sample were found to be 0.991, and the method error estimated using Dahlberg's formula was 0.282 [Table 5].

The mean difference between estimated dental age and chronological age for the sample was 0.01 ± 1.13 (P = 0.77). The results obtained showed no statistically significant difference in the estimated dental age and chronological age. The mean difference between estimated dental age and chronological age for males was 0.004 ± 1.08 years (P = 0.949). It varied from − 0.31 years in 10–11 years old to 0.33 years in 6–7 years old.

The mean difference between estimated dental age and chronological age for females was 0.031 ± 1.18 years (P = 0.728). It varied from −0.17 years in 11–12 years old to 0.77 years in 6–7 years old [Tables 3 and 4].

The "*r*" value representative of Pearson's correlation coefficient of dental age and chronological age was close to 1 for both males and females in the sample. It was 0.90 in males and 0.87 in females.

DISCUSSION

Dental maturation is less variable and comparatively free of ethnic differences than other features in human beings.[20,21] However, to solicit the most accurate results, dental age estimation methods should be described individually for different populations, and its applicability in various age groups of both the genders should be accurately analyzed.

Gender-wise applicability of Willems method in the population

In the present study, no statistically significant difference in the estimated chronological age and dental age estimated using Willems method was observed, albeit a mild overestimation of 0.04 ± 1.08 years in males and 0.03 ± 1.18 years in females.

The results of the present study were in concordance with the pioneer study conducted by Willems *et al*. on 3–18-year-old Belgian children. They observed small overestimation in males (0 ± 0.9 years) and females (0.2 ± 1.3 years) when using the modified Demirjian method.[14]

Conflicting studies that reported both significant underestimation and overestimation of dental age using Willems method are reported in literature. Mani *et al*.[8] observed a significant (P = 0.02) overestimation of 0.55 years in males and 0.41 years in females in a sample of Malay children. Similar results of overestimation were reported by Grover *et al*.[22] in a sample of North Indian children (P = 0.03). On the contrary, Maber *et al*.[15] and Mohammed *et al*.[23] reported a significant underestimation of age (P < 0.01) using Willems method. However, the results of the current study are affirmative of the applicability of Willems method in the study population without any modifying regression equation in predicting the chronological age with a creditable level of accuracy.

The "*r*" value representative of Pearson's correlation coefficient of dental age and chronological age was close to 1. The "*r*" value was 0.90 in males and 0.87 in females, thus suggesting a strong positive correlation between chronological age and dental age of observed samples. This finding was in accordance with the studies conducted by Maber *et al*.[15] and Mani *et al*.[8] which reported higher accuracy of Willems method among males than females. Mohammed *et al*., on the other hand, had reported a "*r*" value of 0.88 in females and 0.71 in males suggestive of a better correlation between dental age and chronological age among girls rather than boys. Similar results were reported by Grover *et al*.[22] Such conflicting reports about higher accuracy of Willems method in either of the genders in a specific population may arise due to multiple factors such as the age structure of the sample, sample size, sampling bias, biological variations of individuals in the sample population, and precision of the evaluation method.

Age group-wise applicability of Willems method

In the present study, the greatest overestimation was found in the age group of 6–6.99 years among males and females. In males, the maximum underestimation was observed in the 10–10.99-year category, whereas in females, it was seen in the 11–11.99-year age group. The variations observed in these specific age groups can be attributed to insufficient individuals of both genders within specific age group samples leading to skewed mean results and wide confidence intervals of the mean age.

According to Ambarkova *et al*.,[18] acceptable range of age difference between estimated and chronological ages in forensic anthropology varies from ±0.5 years as a stringent and up to ±1.00 year as a maximum acceptable difference. In the current study, Willems method met this acceptable age difference in all age groups and was precisely accurate in most age groups.

In the present study, no statistically significant overestimation was observed in children of older or younger age groups. Leur *et al*.[24] in their study observed a significant overestimation of age in the 5–10-year age group in comparison to the older children in the sample ($P = 0.01$). This was contrary to the observations by Maber *et al*.[15] and Eid *et al*.[12] who reported higher variation of estimated dental age in older children.

In the present study, a consistent underestimation was observed among girls in the age group of 9–11-year-old girls and 10–12-year-old boys. Similarly, varying degree of underestimation was reported by Mani *et al*. in children of pubertal age group (13–15-year-old girls) and (14–15-year-old boys). Mani *et al*. attributed this to para-pubertal speed fluctuation leading to faster dental maturation. Hence, it can be hypothesized that the varying level of underestimation in 9–11-year-old girls and 11–13-year-old boys may be related to the globally observed early onset of puberty in the present-day children.[25,26] The above hypothesis can only be confirmed through further study of a possible association between dental maturation and puberty-related changes (menarche in girls and onset of secondary sexual characteristics in boys) in children of this age group.

Further studies involving higher representation of the population, particularly of the younger age groups, can further reduce the disparities and scrutinize the applicability of the method in all age groups.

CONCLUSION

It can be concluded from this study that Willems method can be used to determine the chronological age of North Indian children with good accuracy. It is well established that no age estimation method can accurately determine the exact age of every individual. Moreover, dental age will vary widely among the individuals with the same chronological age.[27] Hence, while estimating the dental age, the most accurate results would be attained if one does not restrict to any one age estimation method but derive the most accurate results by repetitive measurements of different methods reported for that population in the literature.

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Conflicts of interest

There no conflicts of interest.

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