Research Article

Dental age estimation and accuracy assessment by Demirjian, Nolla and Willems methods in Nepalese children for predicting the chronological age

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ABSTRACT

Introduction: Dental age estimation has been performed by numerous methods worldwide. This study was done to evaluate and compare the validity and accuracy of dental age estimation by Demirjian, Nolla and Willems methods in Nepalese children.

Materials and Method: A comparative cross sectional study was conducted on 280 orthopantomography of Nepalese children aged 5-14 years in Kantipur Dental College from December 2020 to September 2021. Dental age was calculated by three methods and difference with chronological age was examined. Descriptive statistics were presented as mean ± SD and median (range). Differences in paired data of chronological and dental ages were examined using Wilcoxon signed rank test. Spearman's correlation coefficient was used for comparing chronological and dental ages. Regression analysis was performed to derive equation for predicting chronological age from dental age.

Results: An underestimation of dental age was observed with Demirjian(-1.17 years), Nolla(-1.06 years) and Willems(-1.32 years) methods which was statistically significant and also across both genders (p<0.001). However, chronological age was found to be highly correlated with dental ages estimated using Demirjian (σ=0.930; p<0.001), Nolla (σ=0.939; p<0.001) and Willems (σ=0.947; p<0.001) methods. Linear regression analysis conducted to predict chronological age showed total variance of 80.8%, 87.7% and 89.5% in boys and 81.7%, 87.7% and 88.4% in girls by Demirjian, Nolla and Willems methods respectively.

Conclusion: This study revealed Demirjian, Nolla and Willems methods can be a valid measure for age estimation among Nepalese children and precise prediction of chronological age can be made from different dental age estimation techniques.

KEYWORDS: Chronological age, Demirjian method, Dental age estimation, Nepalese, Nolla method, Willems method

INTRODUCTION

The assessment of a child's chronological age and stage of maturation is important in fields of pediatrics, orthopedics, orthodontics, forensic, anthropological and bioarchaeology studies.[1,2] Estimation of chronological age (CA) by dental age (DA) estimation has gained acceptance because it is less variable when compared to other indices and less affected by environmental factors.[2-4] Numerous methods have evolved in estimating dental development that includes anatomy, histology, tooth eruption timings, and radiographic evaluation.[5-10]

Nolla, Demirjian and Goldstein, Haavikko and Willem's methods are used for determination of the dental age by observing the progress of tooth calcification from radiographs.[2,5,7,9,11] Demirjian[7,8] method is one of the most popular tools for predicting chronological age due to its simplicity, the degree of intraexaminer agreement and the ease of its standardization and reproducibility.[12] Nolla[5] age estimation method is based on the calcification of teeth and presents a high degree of intra-observer agreement (greater than 90%) but has been used only once in the Nepalese population.[13,14] The Willems[9] method, a modification of the Demirjian

method calculates dental age by direct scoring of tooth development which has provided comparatively smaller overestimations and precise estimation in some populations.[15]

The major bias in age estimation is the differences in growth and development as well as other factors like hereditary, sex, nutrition, function and environment in different ethnic groups of population which must be taken into significant consideration while applying age estimation methods.[12,15]

In the Nepalese population, Demirjian method has been used independently[16,17] as well as with the Nolla method[14] or with Willems in numerous studies.[18,19] However, there have been no comparative studies between Demirjian, Nolla and Willems methods, thus this study aims to evaluate and compare the validity and accuracy of these methods in Nepalese children.

MATERIALS AND METHOD

A prospective cross sectional study was carried out using panoramic digital radiographs of healthy children of 280 patients (140 boys and 140 girls) aged 5-14 years who came to Kantipur Dental College and Hospital, Kathmandu, Nepal. The study was approved from Institutional Review Committee of KDCH with reference number IRC: 02/021. The nature and purpose of the study was explained in detail to parents. A written informed consent was then obtained. Patients were observed between December 2020 and January 2021, and the data were analyzed between January to September 2021.

Study Sample

A total sample size of 280 was calculated using mean difference of 1.995 years and standard deviation of 5.065 years from study by Nyachhyon R et al.[16] at 95% confidence interval and 90% power.

Sample size,   n= $\frac{f(\alpha 1\beta) \times 2x\ SD^2}{D2}$

n= $\frac{10.5 \times 2 \times (5.065)^2}{(1.995)^2}$

n= 135

Sample size was adjusted to 280 to account for gender strata (Male and Female).

Inclusion criteria: Children aged 5–14 years (physically healthy, well-nourished and nonsyndromic) with well recorded name, sex, date of birth and clear digital panoramic radiographs with a full complement of mandibular permanent teeth (erupted or unerupted) without blurring or artifacts with date of radiograph was taken. Patients' records screening was done to

rule out the presence of any medical condition that may affect tooth development. For comparing the Demirjian, Nolla and Willems methods, the radiographs with the presence of seven permanent mandibular teeth on the left side are evaluated by observing the mineralization of these teeth and the age is estimated.[20]

Exclusion criteria: Radiographs where the date of birth and sex were not registered; poor-quality radiographs or image deformity affecting left mandibular permanent tooth that did not allow proper visualization of the degree of dental development; hypodontia of permanent teeth, or radiographs from children with systematic diseases, syndromes, congenital anomalies like cleft lip and cleft palate or dental abnormalities, permanent tooth extraction (except for the third molar), impacted or ankylosed teeth the use of orthodontic appliances or a history of dental trauma or injury to face and gross dental pathology.

Radiographs were selected using the random lottery system function of the Excel 14.0 (Microsoft Office) program from a list of 500 potential children who met the inclusion criteria. All panoramic radiographs of the subjects were obtained from the same Carestream CS 9300 Dental CBCT machine (model CS 9300) in JPEG format. The radiographs were analyzed and each digital OPG was coded with a numerical identity number (1-280) to ensure that the observer was blind to sex, name and chronological age of subjects. After the evaluation of 5 radiographs, the evaluator took a rest period of 10 min and maximum 20 radiographs were analyzed in a day. After the evaluation of all radiographs again after 4 weeks, the evaluator (SL) reevaluated 100% of the radiographs of the total sample using the Willems, Demirjian and Nolla methods. The following data were registered: date of birth, date of the x-ray, sex, and the degree of dental calcification according to the Demirjian, Nolla and Willems methods.

Chronological age (CA) - The chronological age was got by subtracting the date of the orthopantograph taken from the date of birth, converted and kept in decimal.

Dental age (DA) - The dental age was calculated by the Demirjian, Willems, and Nolla methods according to the degree of dental development from seven left mandibular teeth except third molar recording the dental calcification stages in all selected radiographs.

The Demirjian[7] method: The degree of development of each teeth was assessed and classified on an 8-stage scale represented by the letters "A" through "H" according to their degree of mineralization. Using the conversion table, according to sex the letters are

converted to a score which are added up and the result score is converted to dental age according to sex, by relating to the conversion table of the method.

The Nolla[5] method: The degree of dental development of the teeth was assessed by classifying it into ten degrees (0-10) of dental development. A score is assigned to each of the teeth according to sex, which is converted to an average score developed by the authors. The values are added up and the result score is corresponded to the dental age according to the conversion table of the method.

The Willems[9] method: The degree of development of each teeth was assessed using the classification of the method proposed by Demirjian and a score is given to each teeth according to sex, which is converted to an average score developed by the author. All the values are added up and the result score corresponds to the dental age.

Statistical analysis

The obtained data were tabulated and analyzed using SPSS V20.0 software package. Descriptive statistics like mean (SD) and median (range) were used for chronological age and dental age. Shapiro-Wilk test, applied to determine normality of the data, showed a nonparametric distribution. The Wilcoxon test for paired data was applied by age groups and sex to compare the chronological age and dental age of each method (Demirjian, Nolla and Willems). The difference between CA and DA was calculated where the positive result value indicated an overestimation and a negative figure indicated an underestimation. Spearman's correlation coefficient was applied to assess the correlation between the chronological age and dental age of each method (Demirjian, Nolla and Willems). A linear regression model was used to obtain a parsimonious model allowing the chronological age to be estimated from the measurements taken of the seven mandibular left teeth with each of the methods and grouped by sex. Intra-class correlation coefficient were used to assess intra-observer reliability for different methods. To perform the sample calculation, the paired test was used to compare correlated measures specifying the standard deviations of the differences. Statistical tests were performed at a 95% confidence level with the SPSS V20.0 software package.

RESULT

The relationship between chronological and estimated Dental ages was evaluated by each methods (Demirjian, Nolla and Willem) and across both genders. The mean CA of the participants was 10.02 (2.92) years. The mean CA for boys was 10 (2.94) years and for girls was 10.04

(2.90) years. The sex distribution was similar among study population; Male 140 (50%) and Female 140 (50%).

The mean dental age calculated with the Demirjian method was in general 8.85 (2.38), of which that of boys and girls was 8.80 (2.32) and 8.91 (2.45), respectively. Similarly, the mean dental age calculated with the Nolla method was 8.96 years (2.00), of which that of boys and girls was 9.18 years (2.08) and 8.74 years (1.89), respectively. The mean dental age calculated with the Willems method was 8.70 years (2.63), of which that of boys and girls was 8.67 years (2.53) and 8.72 years (2.74), respectively. Overall, there was a tendency to underestimate age in all three dental age estimation methods (Table 1).

By the Demirjian method mean DA was underestimated by -1.17 years in whole sample, underestimated by -1.49 years for girls and by -1.2 years for boys, by the Nolla method by -1.06 years in total sample; and by -1.3 years for girls and by -0.82 years for boys and the Willems method by -1.32 years in total sample and by -1.32 years for girls and by -1.3 years for boys, compared to CA (Table 1).

Similarly, the difference in chronological age and dental ages was also examined across different age groups in our study population. In boys, the Demirjian method was more accurate between age groups of 5 to 5.999 years (p=0.158), 6 to 6.999 years (p=0.683) and 7 to 7.999 years (p=0.975); and in girls between 5 to 5.999 years (p=0.551) and 6 to 6.999 years (p=0.730) (Table 2). The Nolla method showed underestimation except in boys at age groups of 5 to 5.999 years (p=0.638), 6 to 6.999 (p=0.331), 7 to 7.999 (p=0.397), 8 to 8.999 (p=0.158) and 9 to 9.999 (p=0.394). Similarly, the technique revealed accurate measure among girls at age groups of 5 to 5.999 (p=0.778), 6 to 6.999 (p=0.177) and 7 to 7.999 (p=0.124) (Table 3). The Willems method showed statistically significant difference when compared with chronological age in all age groups (Table 4).

Spearman's correlation coefficients show strong correlations between chronological age and dental age; the rho values range from 0.93 to 0.95 and are significant in all cases (p < 0.001).The graphs showed positive correlation of the calculation of dental age with the three methods used with respect to chronological age: Demirjian, Nolla and Willems methods (Fig. 1,2,3). For predicting the chronological age, the regression analysis was performed grouped by sex taking into account different dental age as a dependent variable, where it was statistically significant (Table 5).

A predictive capacity of the total variance of the chronological age in the sample of 81.8% for girls and 80.9% was obtained for boys using Demirjian scores, 87.7% for girls and 87.7% was obtained for boys in the scores used for Nolla and 88.5% for girls and 89.5% for boys was obtained in the scores used for Willems.

The equations for chronologically predicting the age using the Demirjian, Willems, and Nolla method scores were obtained (Table 5). By substituting the score obtained with each of the methods in dental ages (DA, WA, NA) to the equation a chronological estimate of age (CA) can be obtained. Intraclass correlation coefficient for repeat examination showed values above 0.93 for all age estimation techniques for a single evaluator.

Table 1: General and sex results of the comparison of chronological age with each dental method

Method	Chronological age		Dental age		Test statistic	Standard Error	p-value*
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
Demirjian	10.02 (2.92)	10.03 (5.10 − 14.98)	8.85 (2.38)	8.60 (3.50 − 16.00)	3378.50	1356.15	<0.001
Demirjian for boys	10 (2.94)	10.04 (5.10 − 14.98)	8.80 (2.32)	8.80 (3.70 − 15.80)	789	480.75	<0.001
Demirjian for girls	10.04 (2.90)	10.02 (5.10 − 14.93)	8.91 (2.45)	8.25 (3.50 − 16.00)	925.5	480.75	<0.001
Willems	10.02 (2.92)	10.03 (5.10 − 14.98)	8.70 (2.63)	8.77 (3.90 − 15.79)	925	1356.15	<0.001
Willems for boys	10 (2.94)	10.04 (5.10 − 14.98)	8.67 (2.53)	9.04 (3.90 − 14.34)	132	480.75	<0.001
Willems for girls	10.04 (2.90)	10.02 (5.10 − 14.93)	8.72 (2.74)	8.49 (3.92 −15.79)	314	480.75	<0.001
Nolla	10.02 (2.92)	10.03 (5.10 − 14.98)	8.96 (2.00)	9.12 (4.10 −12.42)	4887.50	1348.90	<0.001
Nolla for boys	10 (2.94)	10.04 (5.10 − 14.98)	9.18 (2.08)	9.71 (4.10 −12.42)	1758	475.63	<0.001
Nolla for girls	10.04 (2.90)	10.02 (5.10 − 14.93)	8.74 (1.89)	8.64 (4.5 −11.71)	794	480.75	<0.001
*Wilcoxon signed rank test							

Table 2: General and sex results of the comparison of chronological age with Demirjian age

Method	n	Chronological age		Demirjian age		Test statistic	Standard Error	p-value*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
Boys								
5 − 5.999	14	5.38 (0.18)	5.36 (5.10 − 5.74)	5.01 (0.76)	5.20 (3.70 − 6.30)	30	15.930	0.158
6 − 6.999	14	6.49 (0.26)	6.48 (6.10 − 6.93)	6.40 (0.58)	6.45 (5.20 − 7.30)	46	15.930	0.683
7 -7.999	14	7.51 (0.25)	7.52 (7.10 − 7.98)	7.46 (0.31)	7.50 (6.80 − 8.00)	53	15.93	0.975
8 − 8.999	14	8.42 (0.17)	8.51 (8.09 − 8.66)	7.76 (0.23)	7.70 (7.40 − 8.30)	1	14.31	0.002
9 − 9.999	14	9.47 (0.29)	9.52 (9.01 − 9.96)	8.51 (0.76)	8.40 (7.10 - 9.80)	8	17.61	0.003

Method	n	Chronological age		Demirjian age		Test statistic	Standard Error	p-value*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
Boys								
10 − 10.999	14	10.47 (0.29)	10.43 (10.13 − 10.94)	9.62 (0.79)	9.60 (8.50 -11.80)	9	15.93	0.006
11 − 11.999	14	11.41 (0.18)	11.43 (11.10 − 11.63)	9.25 (0.68)	9.10 (8.60 − 11.10)	1	15.93	0.001
12 − 12.999	14	12.50 (0.35)	12.39 (12.10 − 12.96)	10.33 (1.07)	10.15 (8.20 − 12.50)	0	15.93	0.001
13 − 13.999	14	13.67 (0.24)	13.68 (13.11 − 13.93)	11.19 (1.20)	11.05 (9.30 − 12.80)	0	15.93	0.001
14 − 15	14	14.59 (0.30)	14.56 (14.18 − 14.98)	12.39 (2.04)	12.95 (9.00 − 15.80)	6	15.93	0.004
Girls								
5 − 5.999	14	5.48 (0.24)	5.45 (5.10 − 5.94)	5.54 (0.93)	5.80 (3.50 − 7.70)	62	15.926	0.551
6 − 6.999	14	6.56 (0.24)	6.52 (6.16 − 6.94)	6.50 (0.73)	6.75 (5.40 − 7.70)	47	15.930	0.730
7 -7.999	14	7.60 (0.20)	7.56 (7.26 − 7.94)	7.16 (0.67)	7.40 (5.70 − 8.00)	19	15.930	0.035
8 − 8.999	14	8.55 (0.17)	8.60 (8.27 − 8.77)	7.72 (0.43)	7.55 (7.20 − 8.70)	1	15.930	0.001
9 − 9.999	14	9.54 (0.21)	9.55 (9.18 − 9.94)	8.27 (0.49)	8.30 (7.50 − 9.00)	0	15.930	0.001
10 − 10.999	14	10.52 (0.25)	10.52 (10.10 − 10.96)	8.49 (0.86)	8.35 (7.60 − 10.50)	0	15.930	0.001
11 − 11.999	14	11.46 (0.23)	11.41 (10.10 − 11.87)	9.96 (1.18)	10.45 (7.80 − 11.80)	1	15.930	0.001
12 − 12.999	14	12.61 (0.31)	13.60 (12.13 − 12.96)	11.09 (1.14)	11.25 (9.20 − 13.10)	6	15.930	0.004
13 − 13.999	14	13.61 (0.25)	13.60 (13.10 − 13.95)	11.59 (1.37)	11.40 (9.60 − 13.70)	0	15.930	0.001
14 - 15	14	14.50 (0.31)	14.54 (14.10 − 14.93)	12.79 (1.49)	12.80 (10.10−16.00)	7	15.930	0.004
*Wilcoxon signed rank test								

Table 3: General and sex results of the comparison of chronological age with Nolla age

Method	n	Chronological age		Nolla age		Test statistic	Standard Error	p-value*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
Boys								
5 − 5.999	14	5.38 (0.18)	5.36 (5.10 − 5.74)	5.26 (0.57)	5.30 (4.10 − 5.80)	45	15.930	0.638
6 − 6.999	14	6.49 (0.26)	6.48 (6.10 − 6.93)	6.72 (0.50)	6.64 (6.00 − 7.86)	68	15.930	0.331

Method	n	Chronological age		Nolla age		Test statistic	Standard Error	p-value*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
7 -7.999	14	7.51 (0.25)	7.52 (7.10 − 7.98)	7.61 (0.40)	7.50 (7.10 − 8.50)	66	15.930	0.397
8 − 8.999	14	8.42 (0.17)	8.51 (8.09 − 8.66)	8.58 (0.39)	8.50 (7.80 − 9.10)	57	12.748	0.158
9 − 9.999	14	9.47 (0.29)	9.5 (9.01 − 9.96)	9.63 (0.55)	9.71 (8.40 − 10.28)	75	17.607	0.394
10 − 10.999	14	10.47 (0.29)	10.43 (10.13 -10.94)	9.76 (0.31)	9.78 (9.28 − 10.14)	1	15.930	0.001
11 − 11.999	14	11.41 (0.18)	11.43 (11.10 − 11.63)	9.91 (0.45)	9.60 (9.29 − 10.71)	0	15.930	0.001
12 − 12.999	14	12.50 (0.35)	12.39 (12.10 − 12.96)	10.92 (0.49)	10.77 (10.28 − 11.85)	0	15.930	0.001
13 − 13.999	14	13.67 (0.24)	13.68 (13.11 − 13.93)	11.57 (0.90)	12.07 (10.28 − 12.42)	0	15.930	0.001
14 − 15	14	14.59 (0.30)	14.56 (14.18 − 14.98)	11.74 (0.40)	11.78 (10.71 − 12.28)	0	15.926	0.001
Girls								
5 − 5.999	14	5.48 (0.24)	5.45 (5.10 − 5.94)	5.48 (0.37)	5.60 (4.50 − 5.74)	57	15.930	0.778
6 − 6.999	14	6.56 (0.24)	6.52 (6.16 − 6.94)	6.81 (0.60)	6.86 (5.57 − 7.86)	74	15.930	0.177
7 -7.999	14	7.60 (0.20)	7.56 (7.26 − 7.94)	7.26 (0.79)	7.40 (5.50 − 8.50)	28	15.930	0.124
8 − 8.999	14	8.55 (0.17)	8.60 (8.27 − 8.77)	8.13 (0.63)	7.93 (7.28 − 9.71)	16	15.930	0.022
9 − 9.999	14	9.54 (0.21)	9.55 (9.18 − 9.94)	8.76 (0.46)	8.85 (7.85 − 9.28)	0	15.930	0.001
10 − 10.999	14	10.52 (0.25)	10.52 (10.10 − 10.96)	8.57 (0.37)	8.57 (8.00 − 9.28)	0	15.93	0.001
11 − 11.999	14	11.46 (0.23)	11.41 (10.10 − 11.87)	9.57 (0.91)	9.45 (8.28 − 10.85)	0	15.930	0.001
12 − 12.999	14	12.61 (0.31)	13.60 (12.13 − 12.96)	10.62 (0.44)	10.64 (10.00 −11.57)	0	15.926	0.001
13 − 13.999	14	13.61 (0.25)	13.60 (13.10 − 13.95)	11.24 (0.36)	11.34 (10.28 −11.71)	0	15.926	0.001
14 − 15	14	14.50 (0.31)	14.54 (14.10 − 14.93)	10.99 (0.30)	11.00 (10.57 −11.57)	0	15.930	0.001
* Wilcoxon signed rank test								

Table 4: General and sex results of the comparison of chronological age with Willems age

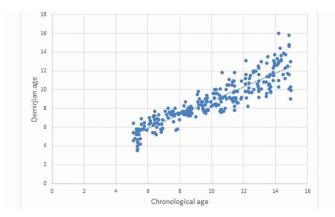| Method	n	Chronological age		Willems age		Test statistic	Standard Error	p-value*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)			
Boys								
5 – 5.999	14	5.38 (0.18)	5.36 5.10 – 5.74)	4.54 (0.41)	4.51 (3.90 – 5.25)	0	15.930	<0.001
6 – 6.999	14	6.49 (0.26)	6.48 (6.10 – 6.93)	5.56 (0.56)	5.58 (4.59 – 6.33)	1	15.930	<0.001
7 -7.999	14	7.51 (0.25)	7.52 (7.10 – 7.98)	6.85 (0.59)	6.82 (5.60 – 7.96)	8	15.93	0.005
8 – 8.999	14	8.42 (0.17)	8.51 (8.09 – 8.66)	7.48 (0.49)	7.40 (6.49 – 8.32)	0	14.305	0.001
9 – 9.999	14	9.47 (0.29)	9.52 (9.01 – 9.96)	8.45 (0.82)	8.58 (6.76 – 9.72)	5	17.607	0.002
10 – 10.999	14	10.47 (0.29)	10.43 (10.13 −10.94)	9.68 (0.64)	9.60 (8.60 – 11.26)	7	15.930	0.004
11 – 11.999	14	11.41 (0.18)	11.43 (11.10 −11.63)	9.71 (0.69)	9.60 (8.93 – 11.75)	1	15.930	0.001
12 – 12.999	14	12.50 (0.35)	12.39 (12.10 −12.96)	10.63 (1.05)	10.48 (9.03 – 12.18)	0	15.930	0.001
13 – 13.999	14	13.67 (0.24)	13.68 (13.11 −13.93)	11.53 (1.20)	11.93 (9.72 – 12.43)	0	15.926	0.001
14 – 15	14	14.59 (0.30)	14.56 (14.18 −14.98)	12.17 (1.22)	12.18 (10.06 −14.34)	0	15.930	0.001
Girls								
5 – 5.999	14	5.48 (0.24)	5.45 (5.10−5.94)	4.82 (0.56)	4.93 (3.92−5.92)	8	15.930	0.005
6 – 6.999	14	6.56 (0.24)	6.52 (6.16−6.94)	5.41 (0.59)	5.29 (4.53−6.22)	0	15.930	0.001
7 -7.999	14	7.60 (0.20)	7.56 (7.26 – 7.94)	6.56 (0.88)	6.58 (4.96 – 8.23)	7	15.930	0.004
8 – 8.999	14	8.55 (0.17)	8.60 (8.27 – 8.77)	7.58 (1.06)	7.26 (6.22 – 9.16)	11	15.930	0.009
9 – 9.999	14	9.54 (0.21)	9.55 (9.18 – 9.94)	8.28 (0.63)	8.21 (7.06 – 9.16)	0	15.930	0.001
10 – 10.999	14	10.52 (0.25)	10.52 (10.10 −10.96)	8.63 (0.91)	8.49 (7.41 – 10.34)	0	15.930	0.001
11 – 11.999	14	11.46 (0.23)	11.41 (10.10 −11.87)	9.99 (1.10)	10.06 (7.89 – 11.27)	0	15.930	0.001
12 – 12.999	14	12.61 (0.31)	13.60 (12.13 −12.96)	11.32 (0.85)	11.18 (10.45 −13.70)	6	15.930	0.004
13 – 13.999	14	13.61 (0.25)	13.60 (13.10 −13.95)	11.80 (0.79)	12.03 (10.79 −12.88)	0	15.930	0.001
14 – 15	14	14.50 (0.31)	14.54 (14.10 −14.93)	12.86 (1.12)	12.74 (11.26 −15.79)	6	15.930	0.004
*Wilcoxon signed rank test								

Fig 1. Graphical representation of the Spearman correlation between the dental age of the Demirjian method and the chronological age
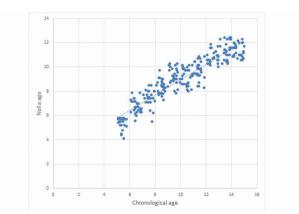

Fig 2. Graphical representation of the Spearman correlation between the dental age of the Nolla method and the chronological age
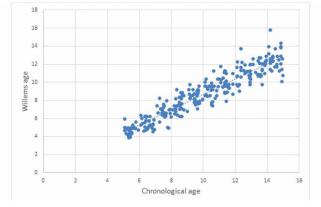

Fig 1. Graphical representation of the Spearman correlation between the dental age of the Willems method and the chronological age

Table 5: Linear regression analysis for predicting chronological age from dental age grouped by gender

	Intercept	R^2	R^2 adjusted	β coefficient	95% CI		p-value	Formula to predict Chronological age (CA)
Demirjian age (DA) for boys	-0.032	0.809	0.808	1.14	1.05	1.23	<0.001	CA = -0.032 + DA for boys x 1.14
Demirjian age (DA) for girls	0.495	0.818	0.817	1.07	0.99	1.16	<0.001	CA = 0.495 + DA for girls x 1.07
Willems age (WA) for boys	0.444	0.896	0.895	1.102	1.039	1.166	<0.001	CA = 0.444 + WA for boys x 1.102
Willems age (WA) for girls	0.995	0.885	0.884	1.359	0.935	1.056	<0.001	CA = 0.995 + WA for girls x 1.359
Nolla age (NA) for boys	-2.223	0.888	0.877	1.331	1.252	1.411	<0.001	CA = -2.223 + NA for boys x 1.331
Nolla age (NA) for girls	-2.528	0.877	0.877	1.438	1.347	1.528	<0.001	CA = -2.528 + NA for girls x 1.438

DISCUSSION

Many methods have evolved for estimating dental age development that takes anatomy, histology, tooth eruption timings, and radiographic evaluation. There is no consensus for the most effective method to predict chronological age.[12] Radiographs are commonly used for dental age estimation because it's convenient and noninvasive.[5]

In our study, children aged 5 to 14 years were taken with an equal proportion of boys and girls and a valid calculated sample for the application of the methods to estimate the dental age. The majority of studies have looked at a single method or two but we have used three methods (Demirjian, Nolla and Willems). In the present study a significant correlation was found between Willems, Nolla and Demirjian methods of dental age estimation with chronological age in Nepalese population. The different dental age estimation techniques can be used to predict chronological age in the study population.

The chronological age was subtracted from the dental age and a positive result indicates an overestimation and a negative figure indicates an underestimation. In this study Demirjian method underestimated age by -1.17 years in whole sample. Similar observations, of underestimation of age by Demirjian's method has been stated in all of the published studies in Nepalese population.[14,16,19] Similarly underestimation in dental age was also observed in few other studies[21-24] while many studies using Demirjian method in several populations[2,4,6,9,13,25-28] have shown overestimation of dental age in contrast to our study. Internationally, using Demirjian method, an overestimation of dental age was found in Brazilians and Croats,[29] Malaysians,[30] Turks,[31] Bangladeshi and British,[32] Indians[2] and Spanish children.[27]

The entire sample in this study showed an underestimation in dental age by -1.06 years using Nolla method which is similar with a Nepalese children study[14] and other population studies.[13,27,33,34] Whereas, Nolla's method has also shown overestimation in young children.[2,35-37] Internationally, Nolla method has shown underestimation in the dental age when applied in Brazilians and Croats,[29] Malaysians,[30] Turks,[31] Bangladeshi and British,[32] Indians[38] and Spanish children.[27]

In this study, Willems method tends to underestimate age by -1.32 yrs in total sample. Comparably, a study done in a small population of Nepalese children also found Willems method to underestimate the dental age.[18] Another study done in Nepal using Demirjian and Willems techniques also showed underestimated dental

age by Willems method.[19] Similarly, studies by Willems method have showed significant underestimation[2,28] and some studies have showed overestimation.[25,39] Internationally Willems method, found overestimation in Bangladeshi and British,[32] Indians[38] and in Spanish children.[27] However, a study carried out by Mohammed RB et al.[2] also in the Indian population reports underestimation with the Willems method.

Our study has used three methods Demirjian, Nolla and Willems which showed delay in the dental age by all three methods. Similarly, in a few studies done in selected Nepalese children population where Demirjian, Willems and Nollas methods have been used separately or in combined form have also found to underestimate the age.[14,16-19]

The application of the Demirjian, Willems and Nolla methods in the same design has been carried out only in four studies.[2,27,32,38] Maber et al,[32] Hegde S et al.[38] and Paz Cortés et al.[27] studies found the Willems method was the most accurate, and together with the Demirjian method, they overestimated the chronological age. The Nolla method underestimated in all three cases. Mohammed RB et al.[2] study showed Nolla's method was more accurate compared to other methods Demirjian and Willems method.

Precision or reliability of estimated age refers to the standard deviation of the mean difference between DA and real age.[2] In this study we obtained a predictive capacity of the total variance of the chronological age of the sample of 88.5% for girls and 89.5% for boys in the scores used for Willems; 81.8% for girls and 80.9% for boys using Demirjian scores; and 87.7% for girls and 87.7% for boys in the scores used for Nolla, indicating the precision was good for all the three methods tested. Similarly, in the study by Paz Cortés et al.[27] a predictive capacity of the total variance of the chronological age of the sample of 79.8% girls and 79.9% boys in the scores used for Willems, 79.0% girls and 79.9% boys using Demirjian scores; and 73.8% girls and 78.6% children in the scores used for Nolla was found. In the study by Melo et al.[34] the precision is very similar to our study with 0.86 and 0.70, girl and boy respectively. However, in the case of the study of Feijoo et al.[26] precision in boys was (0.68) and precision in girls (0.70). In order of precision, our study showed the most appropriate methods for predicting chronological age, in both sexes, were Willems, Nolla and Demirjian methods, respectively.

In the present study, when comparison was done between genders, dental age was greater in girls compared to boys in all three methods. Literature has

reported females being generally ahead of males in tooth formation and emergence.[40]

Dental age was less advanced in the Nepalese children (both boys and girls) and Demirjian, Nolla and Willems methods tend to be less accurate in estimating the chronological age. Thus this study has given the new formulas for forecasting the chronologically age from Demirijian, Nolla and Willems method scores that can be more applicable to the Nepalese children. There is need of population specific formula for age estimation in Nepalese children population which can be used and tested on broader population with inter-ethnic variations for better results in dental age estimation in future. In any legal repercussions where estimation of children's age is needed it is appropriate to use the most accurate dental age calculation methods possible for estimation.

LIMITATION OF THE STUDY

Within a limited population use of lesser no of sample size thus inclusions of larger sample size among larger strata of population including various ethnicities as well can be done for more reliable conclusion in future. Estimation of age can be done by other methods based on the growth of the cervical vertebrae, wrist, or finger bones as studies have shown a positive correlation between bone growth and the state of dental maturation.[41,42] Though we have attempted to derive Nepal specific formulas from Demirijian, Nolla

and Willems method in Nepalese children population, there can still be variations due to different ethnicities in Nepalese population.

CONCLUSION

The study revealed that dental age estimated using three techniques Demirjian, Nolla and Willem are significantly different from the chronological age and all methods underestimated the age in both genders in Nepalese children population. However, the different techniques were highly correlated with chronological age. The chronological age can, hence be predicted using simple linear equations.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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